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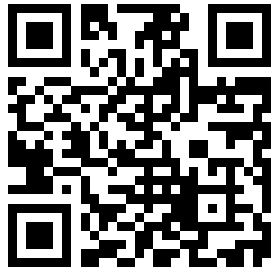

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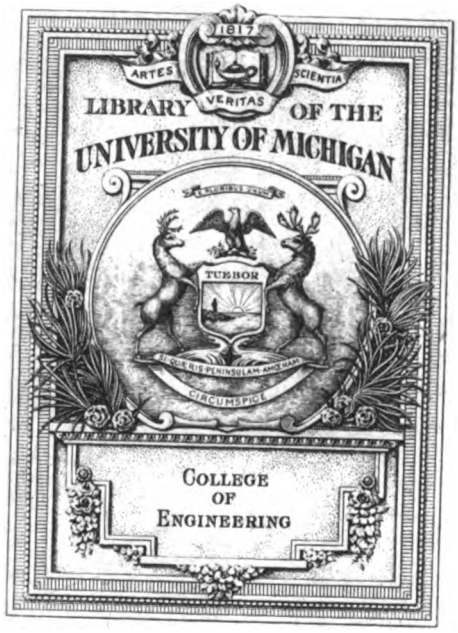

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OW THE "WAR" ENDED

6D MONTHLY

Television

The Official Organ of the Television Society

VOL. 2 MARCH 1929 No. 13

LATEST TELEVISION STUDIO DE LUXE.

The latest Television Broadcasting Studio just completed at the Baird Laboratories is copper lined to eliminate interference from electrical machinery in other parts of the building.

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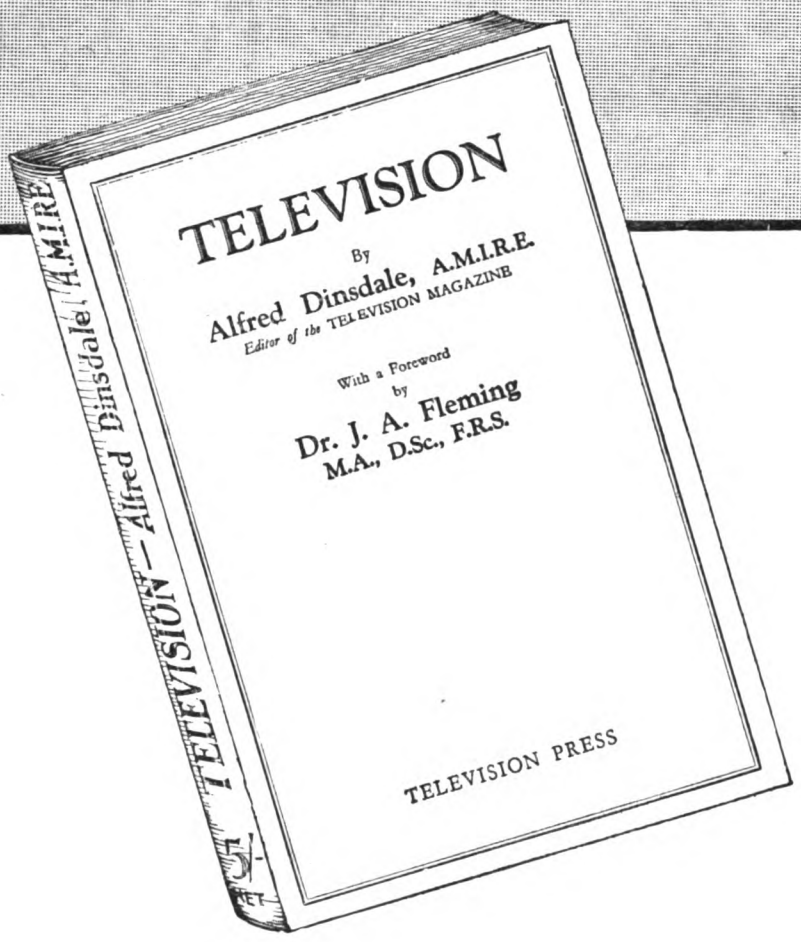

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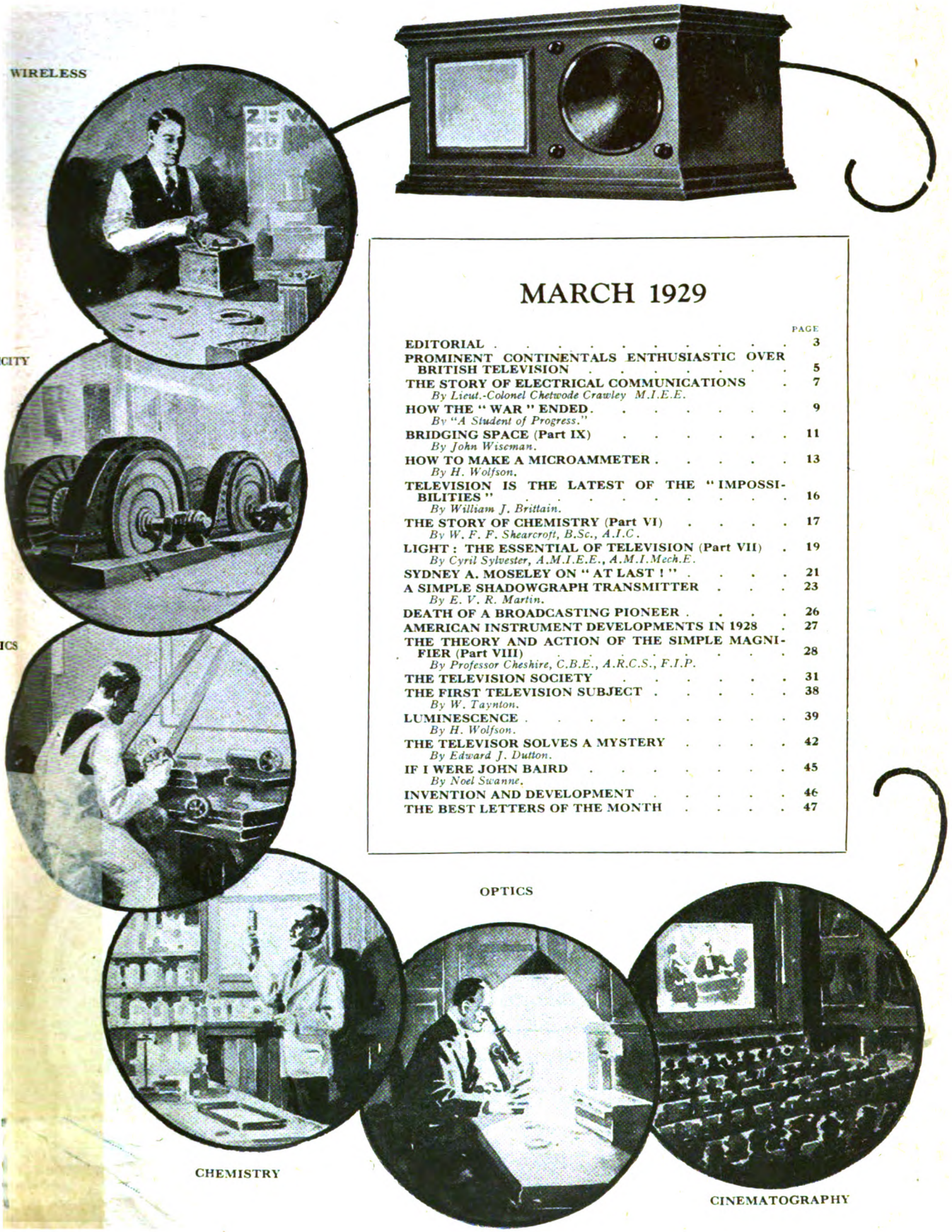

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The Official Organ of The Television Society

Edited by A. DINSDALE, A.M.I.R.E.

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Technical Editor: J. C. RENNIE, B.Sc., A.M.I.E.E.

Vol. 2] MARCH 1929 [No. 13

EDITORIAL

OUR SECOND VOLUME.

THIS magazine has now been in existence one year. With this issue we commence our second volume, and we take this opportunity of thanking our readers for the loyal support which they have given us during the past year. We trust that in the coming year this support will continue and flourish, thus enabling us to extend our sphere of influence and further the cause of the science in which we are all so keenly interested.

* * *

LOOKING back through the pages of Volume I, we find a very complete survey of the elementary principles underlying television and its allied subjects. We find also a very comprehensive record of the progress made in this country and abroad, and many important pronouncements and articles on the subject from the pens of eminent scientists and prominent writers.

* * *

THERE is to be found in those pages a record of our support of, and consistent campaign for, the recognition which is due in this country to the Baird system of television, the only British system. Throughout, we have pleaded for the support of British inventions, lest, as has happened before, they be lost to this country.

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B.B.C. AND TELEVISION.

THROUGHOUT, we have insistently demanded that the broadcasting of television be given a trial through the stations of the British Broadcasting Corporation, under whose auspices such tests must be made in this country, since that body holds a monopoly of broadcast transmission. Our efforts in this direction have met with loyal support from Sydney A. Moseley, whose strenuous activities in this direction appear to have met with success at last.

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A VEIL of secrecy prevents us from obtaining a clear view of the situation as it is at the moment, but judging from reports which have appeared in other sections of the Press, from the speech of the Chairman of the Baird Television Development Co. at the recent annual meeting, and from Mr. Moseley's article in this issue, our efforts would appear to be on the verge of being crowned with success. In another article "A Student of Progress" paints the other side of the picture, and gives us what he believes to have been the B.B.C.'s real attitude towards the question of broadcasting television.

* * *

WHATEVER the exact position may be to-day, and despite what has happened in the past, it is in the public interest that a more amicable spirit should prevail, and the available evidence points to the fact that more friendly relations have been established. We congratulate those concerned on having progressed to that extent.

* * *

BOUND VOLUMES.

BEFORE leaving the subject of our first volume, we would draw attention to the particulars given elsewhere in this issue of our special offer of Volume I, handsomely bound, complete with index. For those who wish to bind up their own copies we are supplying cloth binding cases, with index, which they can take, together with their copies, to a local bookbinder and have bound up for a small sum. We have made these two offers in response to numerous requests from readers who wish to preserve in presentable form the first volume of the World's First Television Journal.

WAVELENGTHS FOR TELEVISION.

IN our last two issues we have referred to the present congestion on the normal broadcast wavebands. There are several solutions to this difficulty. In our February issue we suggested that the way out is the discovery of a new method of modulation. The Chief Engineer of the B.B.C. recently read a paper, sponsored by the B.B.C., before the Institution of Electrical Engineers, in which it was suggested that the solution lay in the direction of special aerials which would confine the radiation of broadcasting stations to the limits of their service areas. Our esteemed contemporary, the *Wireless World*, has pointed out on more than one occasion that probably a more practical solution lies in the direction of the limitation of the number of stations and the granting of permission to increase power.

* * *

TAKING existing conditions as they are, however, it struck us a year ago as being extraordinarily remarkable, and demonstrative of an incredible lack of foresight, that the International Wireless Conference, held at Washington, did not make any provision for television. One of the functions of the conference was to allot on an international basis wavelength bands for every conceivable purpose. Its decisions will hold good indefinitely. The last international conference was held in London in 1912, and the decisions then reached were antiquated and hampering to wireless development for years before the Washington Conference was held. Is television in danger of being held up on account of the lack of provision made for it at the recent conference?

WE are reminded of this matter by Commandant Brenot's pronouncement, reproduced on page 5, which shows clearly that the delegates to the conference did not then appreciate the significance and impending importance of television. Commandant Brenot attended the conference as a delegate of France.

* * *

IMAGINATION versus TELEVISION.

IN its issue for February 2nd the *Christian Science Monitor* prints an article which seeks to prove that the addition to sound broadcasting of television would not be a boon but a disillusionment. The argument put forward is that mankind prefers imagination (or anticipation) to realisation, and the following illustration is given: "An Englishman, who knew Russia well and had interpreted its life to his fellow countrymen, listened on the wireless not so long ago to the music of the ballet played at Moscow. He was happy, because he loved the land into which political considerations denied him the entrance."

* * *

ALL well and good for the listener who has been to the country he is listening in to. He knows the terrain and can visualise what is happening. But what of the millions of others who have not been so fortunate as to be able to travel, and whose interest in foreign countries has been raised by broadcasting to such a pitch that they would dearly love to have a glimpse of those countries? Television will provide this majority with the sight which it wants. And the minority can switch off its televisor and let its imagination run riot to its heart's content.

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Prominent Continentals Enthusiastic over British Television

Commandant Brenot, Chief Engineer of "Radio-Paris."

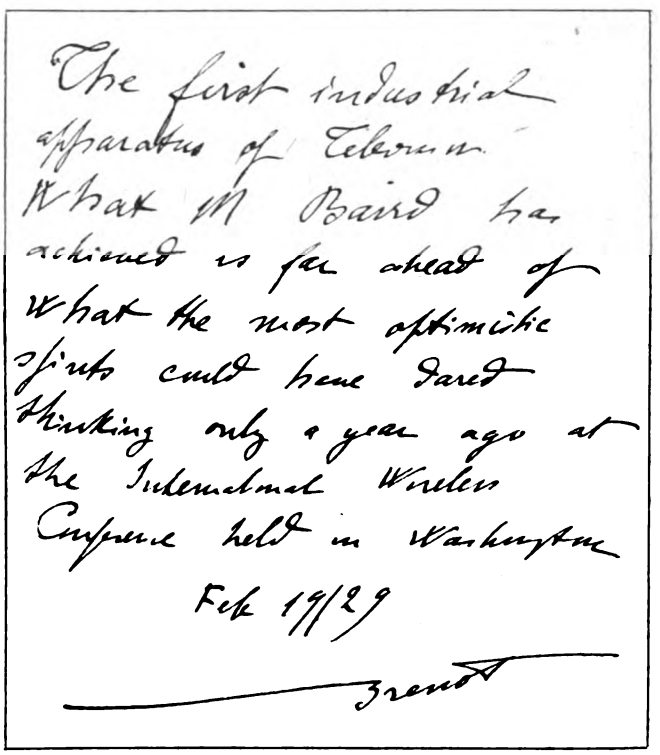
IN our January issue we described how interest in the Baird system of television is rapidly becoming world-wide. We referred in particular to the fact that a company was being formed in France to exploit this British system. Now we are authoritatively informed that, in addition to the other French stations which we mentioned in January, Radio-Paris will also broadcast television.

We are informed that one of the most distinguished visitors to the Baird laboratories recently was Commandant Brenot, Chief Engineer of Radio-Paris, whose photograph appears above. In addition to holding this position, Commandant Brenot is President of the Société of French Radio Dealers and Managing Director of the Société Française Radio Electrique, which owns and supports Radio-Paris.

Originally a pupil (in wireless matters) of General Ferrié, the builder of the Eiffel Tower Station, Commandant Brenot has to his credit the building of Sainte Assise, near Bordeaux, Europe's biggest radiotelegraph station, the Prague and Buenos Ayres stations, and he established the radio-telephonic service between France and America which was recently inaugurated. His achievements during the war earned for him the Legion of Honour.

What this leading French wireless engineer thinks of the Baird system of television is reproduced here in facsimile. As a result of what he has seen in London we are given to understand that he has informed the Baird Company that they may instal "sending apparatus of the Baird television system at the earliest convenience to you for regular broadcasting." This was foreshadowed in our January issue.

Another distinguished Continental visitor, whom



"The first industrial apparatus of television. What M. Baird has achieved is far ahead of what the most optimistic spirits could have dared thinking only a year ago at the International Wireless Conference held in Washington.
"Feb. 19, 1929. Brenot."

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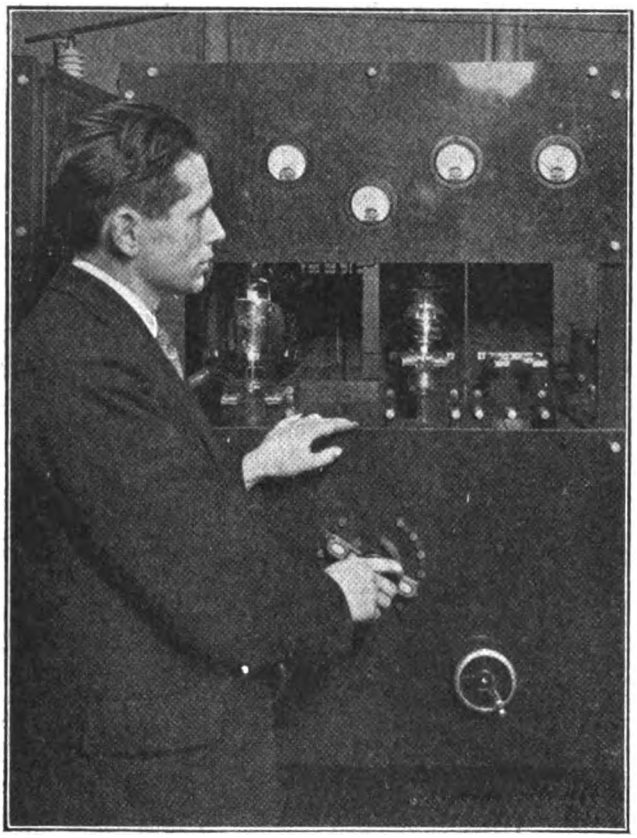
we also had the privilege of interviewing, was Mr. Eduard Svoboda, Technical Manager of the Czechoslovakian broadcasting service. The influence of this service, in which the Czechoslovakian Government retains a 51 per cent. interest, extends into Poland.

Ever since the war Czechoslovakia has been a particularly go-ahead country which has taken the fullest advantage of modern business methods. In the matter of broadcasting stations to-day she is somewhat ahead of her neighbours. She has scrapped inefficient low-powered stations and installed in their place modern high-powered equipments. In Prague there is a 5-kw. (aerial output) Western Electric station; at Brno a 2-kw. Marconi set; a 10-kw. station in Moravia; and plans are afoot for the building close to Prague of a new station which will normally radiate 60 kw. of power, although provision is being made to increase this power at will to 120 kw.



An engineer adjusting the oscillator panel of the Baird Company's new wireless television transmitter on the roof of the Long Acre laboratories.

The purpose of this high-power station will be similar to that of our own 5XX; it will supply alternative programmes, or, according to Mr. Svoboda, the alternative programme may be sacrificed in favour of the broadcasting of television. Mr. Svoboda contends that Czechoslovakia, being in the centre of Europe, must compete with neighbours on all sides, and must emerge supreme in the quality and power of her broadcasting. He declares that by the end of this year Czechoslovakian broadcasting will have reached a very high level indeed.

Questioned on his impressions of what he had seen in the Baird laboratories, Mr. Svoboda was very enthusiastic indeed in his praise of what has been accomplished. "I have no doubt in my mind from what I have just seen here in London that television has definitely reached a commercial stage," he said. "Television to-day is unquestionably much further advanced than radiotelephony was in 1923 when broadcasting was first started. And do not forget that the eye is a much better judge than the ear. The imperfections of broadcasting in 1923, while tolerable then to the ear, would, if we could have seen them, have been quite intolerable.

"All that is necessary now is for television transmitters to be installed, and for television receivers to be made available to the public, and I am convinced that there will immediately be an immense boom similar to that which took place when sound broadcasting commenced. It is inevitable. It must come. With the inauguration of a regular television broadcasting service further improvement is certain to be rapid, as it was in the case of sound broadcasting. But a start must be made."

Questioned regarding television progress in Germany, Mr. Svoboda said that there is no comparison between the German systems and what is being done in this country. He endorses entirely the views expressed by Dr. Alfred Gradenwitz in our issue for December last.

Asked if, before coming to London, he had expected to see such perfect results here, Mr. Svoboda answered in the negative. "I was astonished," he said. "I had heard much about the Baird system. That is why I came; but I never expected to find it so far advanced. People, when they speak of television, have got into a habit of mind such that they say to one another 'Yes, television will be very wonderful when it comes; but it will be another five years or so yet before it comes.' They do not realise that television is *here*, NOW. A start must be made with broadcasting in order to prove to the public that this is so."

Mr. Svoboda gave us to understand that he is very anxious to secure the rights of the Baird system for Czechoslovakia, and such is our admiration for his enterprising country that, on leaving him just as he was departing for home, we were constrained to wish him every success in his efforts.

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The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

Part III.—SUBMARINE TELEGRAPHY

WE have seen how credit for early developments in line telegraphy fell chiefly to Great Britain, America and Germany, but early developments in submarine telegraphy may be credited to Great Britain in the first place with the United States of America as runner-up.

Earliest Pioneers.

The first messages sent by submarine cable were probably those transmitted across a river in India by Brooke, an Englishman, in 1838, though about the same time our old friend Morse, of America, sent messages across the harbour of New York. Morse, as we have seen, was then in the throes of poverty, and it was at this time that he wrote, as has often been quoted, " My stockings all want to see my mother, and my hat is hoary with age."

Cornell, of America, the founder of Cornell University, carried out some successful experiments a few years later, and in 1846 West, of England, had some success with a submarine cable at Portsmouth. West, like Morse, failed for want of money, and in this incident will be seen the reason why, unlike what we found in line telegraphy and what we shall find again in telephony, amateurs have had to yield the palm to professionals in the technical pioneer work of submarine telegraphy.

It is obvious that experiments in submarine working must be very costly compared with line working, and the amateur experimenter is not as a rule a man of great wealth. Neither, for that matter, is the professional, but, other things being equal, wealthy men are more likely to back the professional than the amateur. That is what happened with the first Atlantic cable. To his everlasting credit Cyrus Field, an American millionaire, had the vision to back the scheme.

But we are going too fast. The short submarine cable was a practical proposition before Field stepped in, largely due to the untiring industry and enthusiasm of the brothers Brett, of England, who, entirely at their own expense, laid the first cable across the English Channel from Dover to Calais in 1850. This cable was soon put out of action by a fisherman and his nets, but it had served its purpose ; it was replaced, and others followed.

Transatlantic Pioneers.

Cyrus Field came to England and with others over here backed the Bretts financially, and had the good fortune to enlist the help of Charles Bright, an English electrical engineer. Bright was a born pioneer. He had all the attributes—courage, enthusiasm, ability, and, perhaps not least, poverty and youth. Not poverty of the hoary-hat variety, for poverty, like all else, is comparative. Before he was twenty he was well known in what was then the small telegraphic world ; before he was forty he was known as " the father of the Atlantic cable."

Field's driving power and Bright's technical ability were fortunately supplemented by the genius of Thomson, but unfortunately clogged by the stubbornness of Whitehouse, who had been appointed engineer-in-chief of the scheme. William Thomson, afterwards Lord Kelvin, was an Irishman of Scotch descent. His father's people had come to Ireland from Scotland some two hundred years before, and his mother was Scotch, but he was born in Belfast and can be justly claimed by Ireland. And William Thomson is well worth claiming. He was one of the greatest scientists and one of the greatest inventors, not only of our country, but of the world. At first Thomson was merely on the board of directors, and it was not till August, 1858, that he was appointed engineer-in-chief in place of Whitehouse, whose attitude, to put it mildly, had become insufferable.

Thomson's advice on all matters, and his practical assistance in carrying out tests on the cable, were invaluable. He applied the principles of his mirror galvanometer not only to testing the cable, but to the reception of signals. With Whitehouse's receiver it took 16 hours to pass the first message of 99 words from our Queen to the President of the United States. At this end, where Thomson's receiver was used, it took 67 minutes for the message to be repeated back.

It must be understood that signals through a submarine cable are not only attenuated, but they are very distorted. The signal, in fact, takes an appreciable time to die away, and if the morse code were used, the dots and dashes would run into one another unless the speed of signalling was extremely low, which is quite out of the question for remunerative working.

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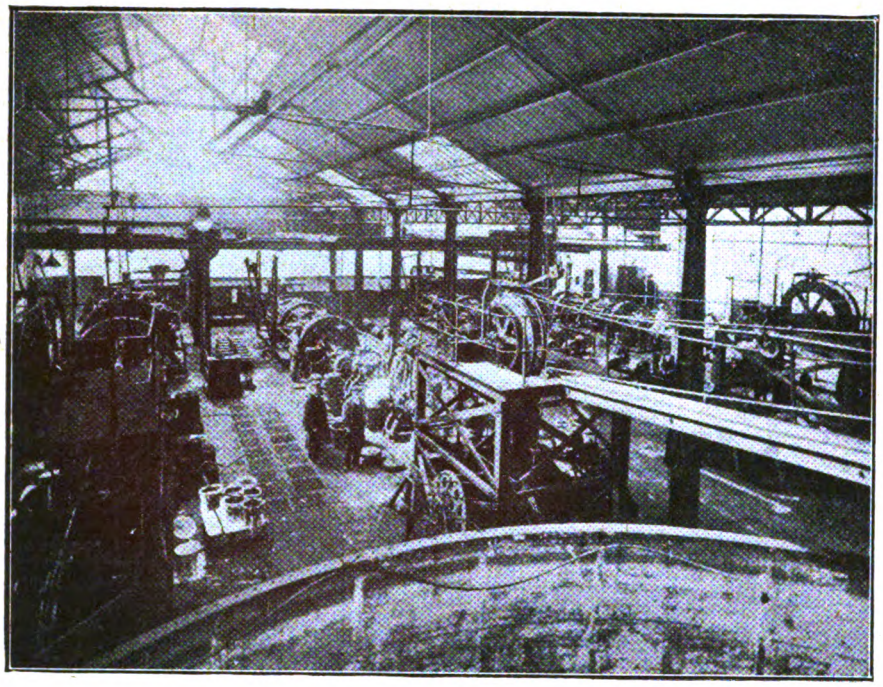


Interior of a submarine cable factory.

The Syphon Recorder.

It was Thomson who first devised a suitable method for sending and receiving signals. He invented the impulse method of signalling, in which a dot is represented by an impulse of positive current, a dash by an impulse of negative current of the same length, and a space between letters by a corresponding zero interval, the message being recorded on the receiving tape in the form of a wavy line.

The receiver which Thomson invented, and which is still used on some cables, is the Syphon Recorder. It consists of a small glass tube shaped like a syphon, with one end immersed in an ink-well, the other end being free to move to and fro across the surface of a paper tape. The syphon is connected to an electro-magnet in the line circuit in such a way that currents in the line produce movements, to and fro, of the syphon across the tape. When the syphon is at rest a straight line is drawn on the tape, but when in movement a wavy line, whose characteristics depend on the signals being received.

The First Transatlantic Cable.

But we anticipate again. Field and his English friends lit the cable torch so well on both sides of the Atlantic that even the Governments succumbed, and on August 6th, 1857, an expedition for laying the first cable set off from Valentia on the south-west coast of Ireland. Each Government had supplied a warship; the American ship was to lay the first half of the cable from Valentia, and the British ship was to continue it from mid-Atlantic to Newfoundland.

Unfortunately, 400 miles out, the cable snapped, and the ships came into Plymouth. More money had to be raised, and again the expedition started off in June, 1858. Terrific weather was encountered, and again there was failure. But once more the money was forthcoming, the attempt was made, and, as in all good fairy tales, the third attempt was crowned with success.

It does not sound much in the telling, but that is only because the difficulties were so great that even a summary of them would require the space of a whole article. All we need say here is that the laying of the first Atlantic cable will rank for ever as one of the epics of scientific achievement.

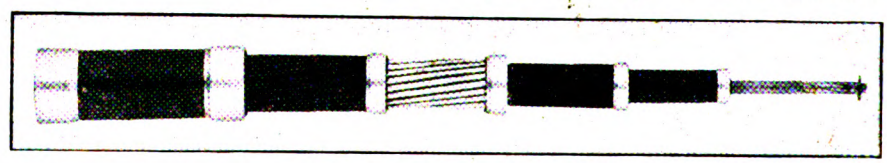
This cable only lasted two months, but over 700 messages had been sent, and the possibility of long-distance submarine telegraphy was proved beyond a doubt; and it was doubt that had been the greatest obstacle of all, as, indeed, was again the case when Marconi was trying to span the Atlantic by wireless telegraphy, 44 years later. It was largely a triumph of youth and enthusiasm. Bright, like Marconi, was only 26 years old when he conquered the Atlantic.

The next attempt was made in 1865, and the largest ship afloat, the "Great Eastern," was used for the purpose. The cable was much stouter than before, and weighed 4,000 tons, but it broke in the laying, and it was not until July 27th, 1866, that at last a satisfactory cable was laid.

Present Transatlantic Cables.

There are now sixteen cables between the British Isles and North America, owned and controlled by one or other of the two great American companies, the Western Union Telegraph Company and the Commercial Cable Company, the two companies which also own the inland telegraph system of the United States, and partly that of Canada. At this end the Western Union cables are landed at Valentia in Ireland, or Sennen Cove near Penzance; the Commercial cables at Waterville in Ireland.

The first of these cables was laid in 1873, and the latest one, a span between the Azores and Newfoundland, last September. This new cable is the world's fastest long-distance cable, capable of transmitting four messages each way simultaneously. It was manufactured and laid by the Telegraph Construction and Maintenance Company, of London, for we still maintain a premier position in constructing and laying cables. The only transatlantic cables controlled by this country are two Government cables, worked at the moment by the Post Office, but shortly to be disposed of to private enterprise under the merger scheme which will be dealt with later.



A section of a submarine cable, showing the various coverings.

Four transatlantic cables between France and North America are controlled by the French Cable Company. The Italian Cable Company controls one from Italy, and the German Atlantic Company have recently laid one from Germany.

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How the "War" ended

By A STUDENT OF PROGRESS

We print the following important article by "A Student of Progress" without necessarily endorsing his views. The personality of the writer warrants the publication and consideration of his opinions—particularly since they help to an understanding of the attitude of the B.B.C. The article, as the writer himself suggests, should be read in conjunction with that written by Sydney A. Moseley.

THE fact that I occupy a position of detachment from the controversies which have raged round television in the past two years may have influenced the Editor in inviting me to contribute to his columns. Anyway, my sole interest is to foster the real progress of the application of science to the needs and happiness of humanity.

In the days when it was customary to throw ridicule upon the broadcasting of voice and music, I was glad to find myself on the side of the pioneers of what has now become, in a few short years, a tremendous beneficent force in the community. That the instrument of broadcasting should have been so wisely conceived and conducted in this country is a matter for gratification among all British people. I hold no brief for the B.B.C., but when I notice the intemperance of some of its critics I am moved to suggest a readjustment of perspective. When all is said and done, the B.B.C. is carrying out its policy of providing in nearly 90 per cent. of the homes of Britain the best available entertainment, thought, culture, and general enlightenment. Moreover, the B.B.C. is miles ahead of any other similar organisation in the world both in the efficiency of its entertainment and in the social value of its work. Having said this one is entitled to criticise as much as one likes!

B.B.C. Procedure.

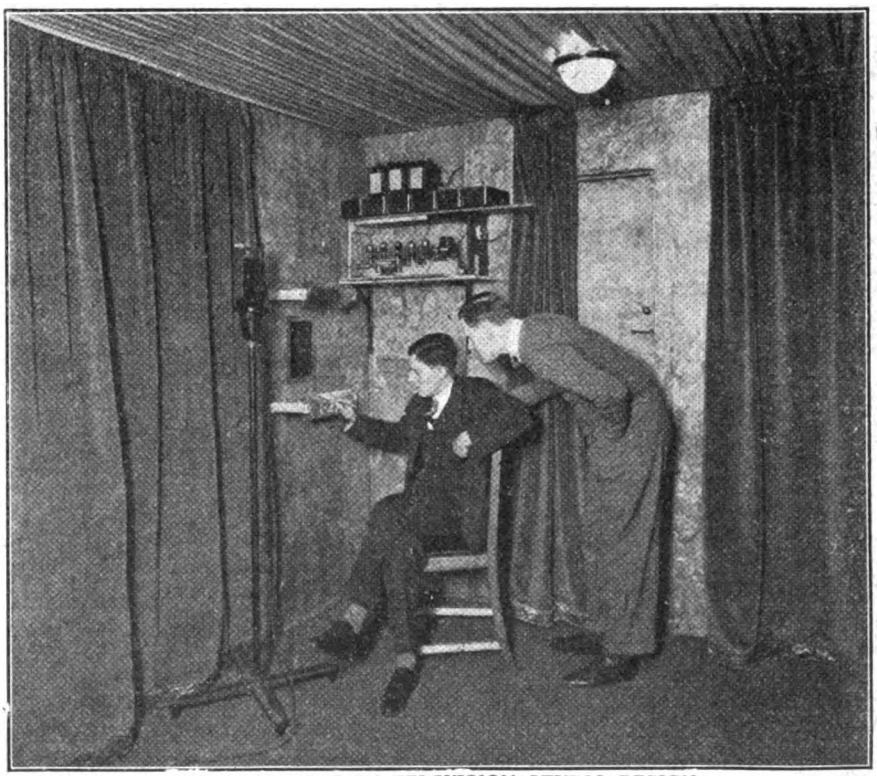
I do not agree with all that the B.B.C has done and failed to do in connection with scientific development. But I understand and appreciate the motives that lie behind its necessarily conservative attitude. Many new inventions and ideas are constantly being brought to Savoy Hill, where they are examined with care and consideration. If they are regarded as being of potential value in a general service sense then they are taken up, developed, and ultimately incorporated.

This general procedure, unfortunately, was not applied early enough in the case of Baird television. Unhappy concatenations of circumstances conspired against the invention. Some of the most zealous and coherent of its earliest advocates happened to have been bitter opponents of the B.B.C., and with their advocacy of television linked a demand for the dissolution of the B.B.C. On the one side irrational claims were made; on the other side was incubated an attitude of intolerance and resentment. The normal channels to coöperation were closed and secured. This was four years ago. The merits of Baird television became obscured in the repeated skirmishes of personalities.

Uninspired and uncontrolled by the Baird companies, the "City" took a fancy to television. There was speculation with all the consequent suspicions. Meanwhile the inventors and research engineers were steadily "plugging away" in the Baird laboratories. But still other considerations stood in the way of coöperation with the B.B.C. Effort on both sides seemed to be much more concerned with increasing the gulf than in building a bridge.

"Spirit of Distrust."

To get the discussion placed on a



THE LAST WORD IN TELEVISION STUDIO DESIGN.
A new television broadcasting studio which has just been completed in the Baird Laboratories is completely lined with copper for the purpose of screening off interference.

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proper technical basis was the task undertaken by well-disposed people last autumn. But it was not possible to exorcise the spirit of distrust at once. The inspection by the B.B.C. in October was a real advance, significant of the first practical contact in four years. The verdict was not liked by the Baird people, who failed to understand that, in view of all that had gone before, it was the only possible one. The B.B.C. said, in effect, that they were distinctly impressed with Baird television, but that it was still in the laboratory stage. If, however, it was improved they would be glad to come and examine it again. Implied in this verdict was the offer of technical assistance, if sought.

Two important mistakes were made on both sides. The Baird engineers declined to allow Captain Eckersley to see the transmitter, thereby losing a golden opportunity of interesting him personally. The Baird interests regarded the verdict as a declaration of war, and acted accordingly, paying no attention to the real possibility of constructive coöperation contained in the B.B.C. verdict, and declining to recognise the *bona fides* of the B.B.C. engineers.

The B.B.C., on the other hand, might have been more cordial, and gone farther towards coöperation; and secondly, should not have published its verdict in advance of communication to the Baird Company. So, on the whole, there was not left very much but the wreckage of good intentions.

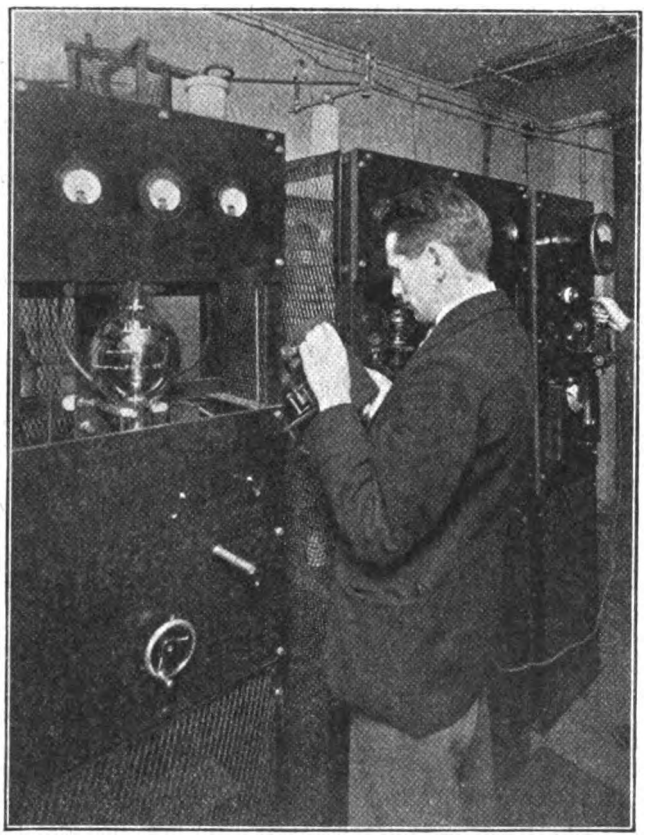
War was resumed; as sterile as most wars. And then after a period of this unprofitable exchange of acerbities, some *thinking* was resumed. Common sense slowly asserted itself. Forces of reconciliation and understanding were set in motion. Executive chiefs were brought together in friendly conference for the first time. Various proposals were considered in an entirely new spirit. At the time this is being written considerable progress is being made. It has been possible, for instance, for both the President of the Board of Trade and the Postmaster-General to call attention to the new spirit in the House of Commons. Pledges of secrecy must be observed as to the details and nature of concrete proposals. Nevertheless, the outstanding fact is that the almost traditional war between the Baird companies and the B.B.C. has been brought to an end—it is hoped for good.

What of the future? I would venture to predict with some confidence that even if the Baird system is still regarded as in need of development to fit in with a broadcasting service in conjunction with the broadcasting of sound this will be undertaken with greatly strengthened technical resources, and with the goodwill of the B.B.C. readily available. And one final word.

Many hard things have been said about Captain Eckersley in this connection. I want to impress readers of this journal and friends of television generally that I am sure Captain Eckersley has done nothing that he did not regard as his absolute duty from the beginning. It would be well if some of his traducers would stop to reflect how much easier it would have been for him to have allowed his technical doubts to be overcome in order to share in the limelight and glamour of hastening the advent of a revolutionary invention.

When the full history of these transactions and events emerges from the facile pen of Sydney Moseley—himself a principal protagonist for the cause of recognition—I believe it will be discovered that, taking the long view, Captain Eckersley's honest doubts and opposition have really served the progress of the application of science to the needs and happiness of humanity.

Those whose duty it is to think in terms of service to millions must put the brake on the natural enthusiasm of those whose sole concern is inventions—the more wonderful and compelling the more calculated to invert perspective.



One of the Baird Company's engineers checking the wavelength of the wireless television transmitter on the roof of the Baird Laboratories.

BAIRD TELEVISION DEVELOPMENT COMPANY MEETING.

In the House of Commons recently Mr. Thurtle asked the President of the Board of Trade if he was aware that the Baird Television Development Company, Limited, had not held any annual meeting or submitted any accounts and balance sheet since the company was floated in 1927, a period of more than eighteen months; and if he was proposing to take any action to enforce the law against this company.

Sir P. Cunliffe-Lister: "I understand from the chairman of the company that the meeting was deferred in view of negotiations with the General Post Office and British Broadcasting Corporation, which were in progress in the latter part of the year for the provision of facilities for an experimental broadcast of television, that arrangements have only just reached a stage at which progress can be reported to the shareholders, and that a general meeting is now being convened. In the circumstances, I do not think that any action on my part is required."

The first annual meeting of the Company was held on Feb. 19th, at which the Chairman, Sir Edward Manville, repeated the above explanation of the delay, and foreshadowed "interesting developments" in the near future.

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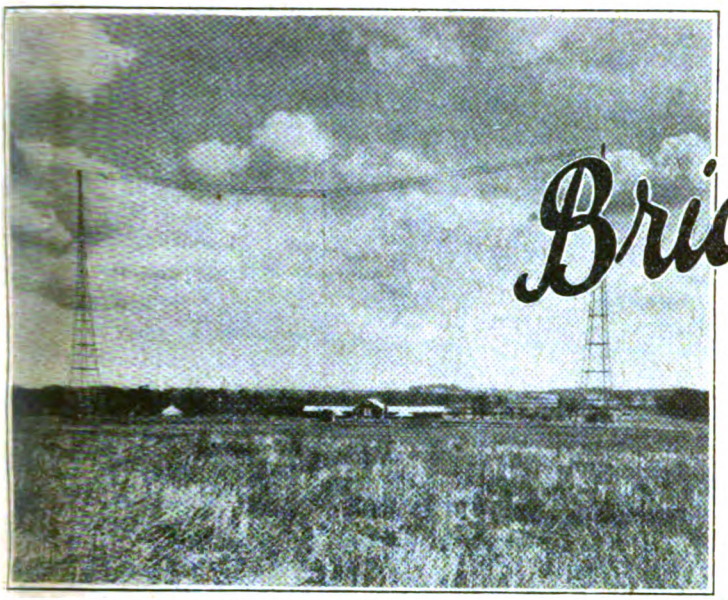


Bridging Space

by

JOHN. WISEMAN

Part IX.—THE RECEIVER

IN our last article we left the modulated carrier wave travelling in all directions from the transmitting aerial, and hinted that the next obvious course was to establish ourselves at a receiving station and see how the broadcast energy could be harnessed, and in effect make it retrace its steps by reproducing at the receiving end all that happened at the transmitting studio.

The first requirement, of course, is a good aerial, such as the one shown in the accompanying photograph, and since we have seen in earlier articles how the transmitting aerial was evolved, we need not go into the matter again, as electrically the receiving aerial is the same as the transmitting aerial. That is to say, it possesses an open or distributed capacity, due to its elevated position, while additional inductance and capacity is invariably provided by locating an inductance or loading coil in the down lead, together with a variable condenser (see Fig. 1). The frequency of any natural aerial oscillations is a function of the total inductance and capacity, and by making one (or both, if required) of these variable—generally the condenser—we can control this factor, and this is extremely important, as we shall see in a moment.

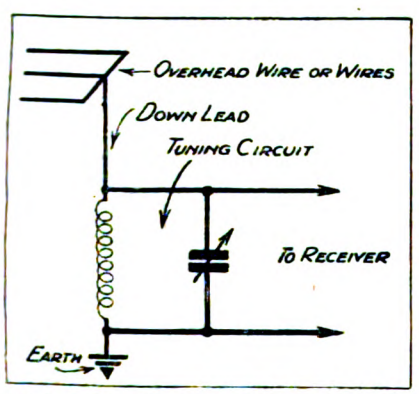


Fig. 1.—Diagrammatic representation of the receiving aerial circuit.

Relative Effects.

Regarding our aerial as a whole it acts as an absorber of some—actually an extremely minute fraction—of the energy from the "wireless" waves. Originally we made an oscillating current in the transmitting aerial produce an electromagnetic field which spread out into space, and this field has the property of inducing a small amount of energy into the receiving aerial as it sweeps across. It is a well-known property of electricity that if a conducting wire is moved across a magnetic field a voltage difference is produced across its extremities, so that if the wire forms part of a closed circuit a current will flow.

Now, although the down lead of our aerial does not actually move through a magnetic field, in a relative sense the effect is the same if the magnetic field moves across it. It is immaterial whether you run up a flight of stairs or keep stationary and allow the stairs to move and take you along, as in the underground escalators; you will reach the top just the same.

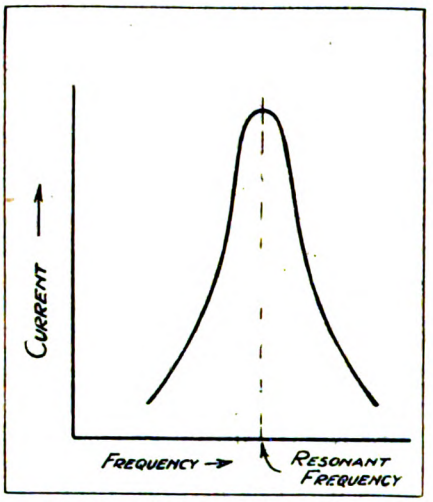
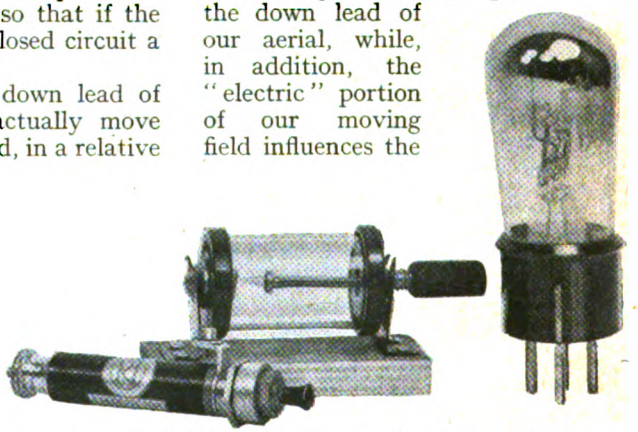


Fig. 2.—A typical resonance curve.

An Exact Replica.

A voltage is therefore produced in the down lead of our aerial, while, in addition, the "electric" portion of our moving field influences the



Three typical detectors—two crystal and one valve.

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condenser section of the aerial and the combined effect is to produce a very small voltage between the top of the aerial and earth. But since our incident electromagnetic waves are alternating in character the voltages produced are alternating, and we really have an exact replica of the original oscillations in the transmitting aerial, but, of course, very much feebler in strength.

Selecting the Signal.

It is at this stage that we can see how necessary it is to be able to select just the signal we require in order to pass it on to the receiving set. A number of other transmitting stations, within range, are sure to be sending out signals simultaneously with the station, the signals of which we desire to receive, and consequently the receiving circuit must possess the ability to " tune out " the unwanted signals which are reaching the aerial and " select " that signal sent by the station with which we desire to communicate. Without this means of selecting a desired signal we should be in a very unfortunate position, but happily the problem is easy to solve.

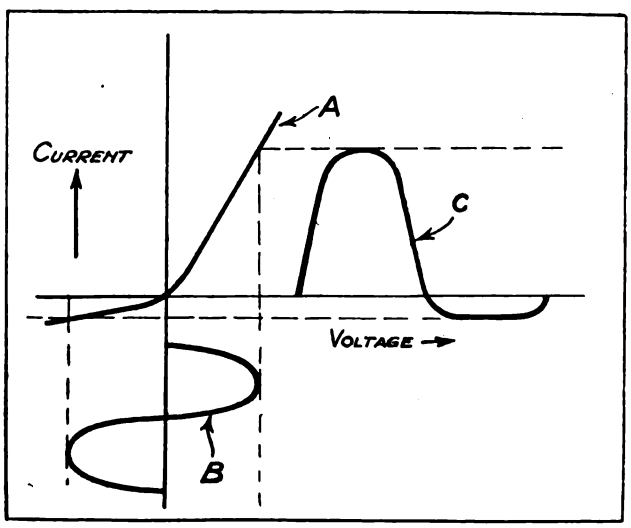
Earlier in this series we saw how the oscillation frequency was a function of the inductance and capacity in the circuit. Consequently, to make this current in the aerial assume its maximum value, we must adjust these electrical quantities so that the aerial's natural frequency coincides with the frequency of the impressed E.M.F. imparted by the electromagnetic wave. This process is called " tuning the aerial," and we actually bring it into resonance with the frequency of the incoming wave.

A WELL-INSTALLED AERIAL.

This resonance effect is encountered in a similar manner in many mechanical ways. It is the reason why soldiers are made to break step when crossing a none too safe bridge, for if the slight shocks given to the bridge by their tramping feet are in the natural period of the bridge they may set up such violent oscillations as to break the bridge.

Resonance.

To revert to our aerial, then, by tuning it to the frequency of the signals it is desired to receive, the current due to these signals is made a maximum, while the currents flowing in the aerial due to signals sent out from other stations which have a frequency differing from that of the signal being received are relatively much weaker. If we had a sensitive meter in the aerial circuit and plotted a curve between current and frequency it would resemble that of Fig. 2.



Typical Detector Curves.

It will be noticed that the current falls off rapidly on either side of the resonant condition. Of course, in actual practice there are other factors which have a distinct bearing on this problem of selectivity—efficiency and resistance of aerial, type of coupling between aerial and receiver, number of tuned circuits employed, etc.—but since these are side issues as far as we are concerned, and do not affect the principles under discussion, we must pass them over and examine the next important detail of our receiving equipment.

Making the Signal Perceptible.

How can we make these very feeble oscillations in the aerial perceptible to the ear for speech broadcast, or visible to the eye for television broadcasts? Taking the speech case, our first thoughts would lie in the direction of the employment of a telephone receiver similar to that shown in one of last month's diagrams. However, if these rapidly oscillating currents were passed direct through such an instrument it would fail to respond. The currents moving first in one direction and then in another at frequencies reckoned in hundreds of thousands pass too rapidly to produce any effect on the diaphragm, owing to mechanical inertia.

We must provide a piece of apparatus which will reduce these effects to audibility, and yet retain the true character of the signal.

(*Continued on page* 15.)

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How to Make a Microammeter

By H. WOLFSON

In the following article our contributor describes, in a simple manner, the construction of a microammeter suitable for the use of the experimenter. Such an instrument has a multitude of uses in the laboratory, and will well repay the amateur for the trouble taken to make it.

AN instrument capable of detecting and measuring extremely minute currents has a wide sphere of useful application both in radio and in television. Unfortunately commercially made instruments are usually too expensive for most of us, and I determined to try and design one which could be made quite easily at the cost of a few shillings. The result has been really surprising, and I have made a really sensitive instrument for the small sum of 5s. 6d.

Let us first consider briefly the theory of the instrument, which is of the suspended coil type. In this instrument we have a coil of wire suspended in a powerful magnetic field. This is shown diagrammatically in Fig. 1, where *N* and *S* are the poles of the magnet, and *CC* represents a section through the coil. The dotted lines and arrows indicate the direction of the magnetic field and the field due to the coil. The forces which are brought into play as a result of the two fields result in a couple being

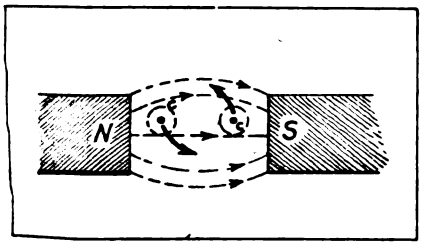

Fig. 1.
Theoretical diagram, showing lines of force due to magnet, and direction of motion of coil CC.

applied to the coil, thus causing it to move in the direction shown by the large arrows.

In order that the deflection of the coil shall be proportional to the current flowing through it for all values of the current, it is essential that the magnetic field shall be uniform for all positions of the coil; this is known as a *radial* field. We shall see how this is achieved when we discuss the actual constructional details.

Since the coil is suspended it will act as a pendulum system, and will thus oscillate about the point to which it has been deflected for a few seconds before it finally comes to rest. This is, of course, inconvenient from the point of view of being able to take readings quickly, and it is usual either to wind the coil on a copper frame, or alternatively to surround the coil with a copper case, constructed of very thin foil, since it is necessary to keep the weight of the coil system as low as is possible.

The Magnetic Field.

The magnetic field required by the instrument is provided by two ex-Government magnets, of the type used for magneto ringers in field telephone sets. These can be obtained from a number of firms who deal in ex-Government stock, for a shilling or so each. As previously stated, the magnetic field must be uniformly distributed. This is quite easily achieved by the use of soft iron-pole pieces. For the construction of these you will require a piece of soft iron of dimensions 1¾ in. long by ¾ in. wide, and 1½ in. deep. This has now to be drilled with a ⅝ in. hole through its centre as shown in Fig. 2. Since many of us are not prepared to drill this hole ourselves, it is best to get the hole drilled at the same time as you purchase the iron. Many firms who deal in iron girders, etc., will supply you. I obtained my piece ready drilled for the small sum of sixpence!

Having obtained the drilled piece of iron, the next operation is to file it true, and make it so as to fit tightly between the poles of the magnet. Having done this, the iron must be sawn into halves.

This requires some care to make quite sure that the cut is made exactly across the centre of the hole, and that it emerges centrally at the other side. You will need a really good hacksaw blade to do this easily and satisfactorily, and any trouble expended will be amply repaid when the instrument is put into commission. The inside of the hole can

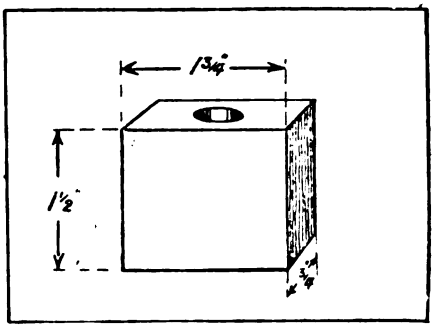

Fig. 2.
Showing block of iron with ⅝ inch hole drilled through.

now be trued up with emery paper and any burrs and inequalities remaining from the sawing can be carefully removed with the file. The object in view is to secure these pole pieces to the magnets so that there is a narrow gap between the pieces, this gap not exceeding ⅛ in. (Fig. 3).

You will be wondering how the pole pieces are to be secured to the magnets, for it is well-nigh impossible to drill the hardened cobalt steel of which they are made. Fortunately there is no need for this, as the use of two magnets in place of one gives us an alternative.

If we drill the ends of the pole pieces centrally, as shown in Fig. 4a, and tap the holes with any convenient thread, say 2BA, we can pass the securing bolts *between* the magnets, as illustrated in Fig. 4b. A large washer should, of course, be placed on the bolt before screwing it tight. It is unnecessary to drill holes right through the pole pieces, so that they

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cut through the cylindrical part, the depth of the hole need be no more than ⅜ in.

At this stage it is best to make the

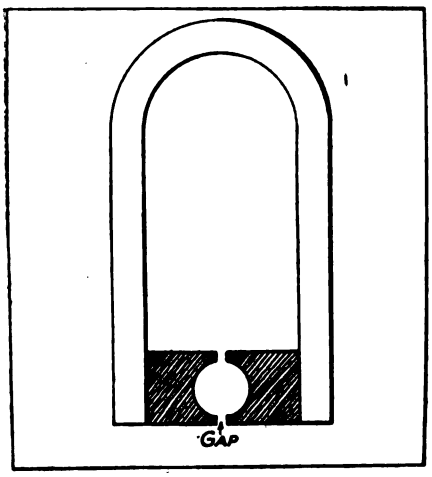

Fig. 3.
Pole pieces shown shaded.

case for the instrument. This can be left largely to the personal fancies of the constructor, so that a brief outline will suffice. I myself was fortunate in having an old mahogany box of suitable dimensions—namely, 4½ in. by 5½ in. by 2¼ in. deep. To this is fitted a cover of ebonite, and in this respect I would advise constructors to adhere to this, as the appearance of the instrument is thereby much enhanced. This piece of ebonite completely covers the top of the box, and must be cut out as is illustrated in Fig. 5, so as to form a window through which the movement of the pointer is followed.

Preparing the Case.

The method of cutting out this window is as follows. Having decided where the centre of the pole piece system will come under this cover when the apparatus is assembled, a slight mark should be made in this position, which will be about one inch from the edge of the ebonite (*C* in Fig. 5). With this as centre, an arc of a circle of radius four inches should be described; this is shown at *AA* in Fig. 5.

A straight line is also drawn under this arc, at a distance of 2¾ in. from the centre mark (*C*, Fig. 5). The constructor should then decide the width of the window and mark off some convenient distance from the edge of the ebonite along the arc. In the instrument which I constructed this distance was ¼ in. From these two marks straight lines should be drawn to the centre of the arc, *C*. These will, of course, cut the straight line, and thus there will be the outline of the window, *AALL*. This should now be cut out of the ebonite, and though various methods of procedure may be adopted, perhaps the most convenient is as follows.

First drill four small holes at the corners of the window and then a number of larger holes near to the edge of the outline, care being taken not to cut into this outline. It is then an easy matter to insert either a hacksaw blade or a fretsaw, and remove the portion marked out. It is advisable not to work too near to the line, as it is easy to run outside the line, which would, of course, spoil the neatness of the job. The final trimming is best accomplished by the use of a flat ward file.

A piece of glass is next cut to fit the ebonite, or, if the reader prefers, any glazier will cut the piece to order. This can be fitted by carefully

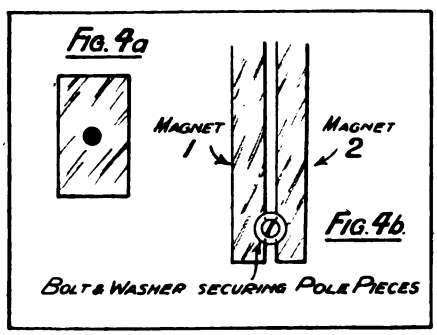

Fig. 4.
(a) End view of pole piece showing tapped hole for securing to magnet. (b) End view of magnet system.

"springing" it into the ebonite, and if of the correct size will hold without any other means of support.

The final piece of drilling is to make a 1¼-in. hole in the ebonite to accommodate a piece of ebonite tubing, of internal diameter 1 in. and length 3 in., which should be procured before the drilling is commenced. The hole should be of such a size as to take the tube very tightly, so that there will be no need to fasten the tube by any other means.

This hole should be drilled at the point *C*, which was the centre from which the other lines were marked out.

The external part of the instrument is completed by fitting to the top of the ebonite tube, which projects from the panel, a knob of the type employed for condensers, etc., and about 1½ in. in diameter. This may have to be filed down somewhat to make it fit tightly and a hole should be drilled through its centre so as to register with the threaded hole in its centre, for it is through this hole that the supporting screw will project into the tube.

Coil and Suspension System.

Having completed the foregoing parts of the construction we are now at liberty to tackle the most delicate and important part of the work. I refer to the coil and its suspensions system. This need present no difficulty if the instructions are adhered to, and can be completed in less than an hour. First choose a well-seasoned, straight-grained, piece of wood, such as canary wood, and trim out a piece 1½ in. long and ½ in. wide. The wood employed should be ¼ in. thick. Reference to Fig. 6 will make matters clearer. The coil former is made from this piece of wood by filing a groove ⅛ in. deep and 3/16 in. wide all round the wood, as shown in Fig. 6. Two brass pins should be firmly driven into the two top flanges of the former, as illustrated, to be used for the suspensions and connections.

The wire used in winding the coil should be 47-gauge enamelled copper wire. This can be conveniently obtained from old Ford coil secondaries, or purchased from scientific suppliers. Half to one ounce will suffice for several coils.

Having removed the enamel from a few inches of the wire by gentle friction with a piece of glass paper, several turns are wound round the pin and secured by soldering. Care must be taken both at this stage and while

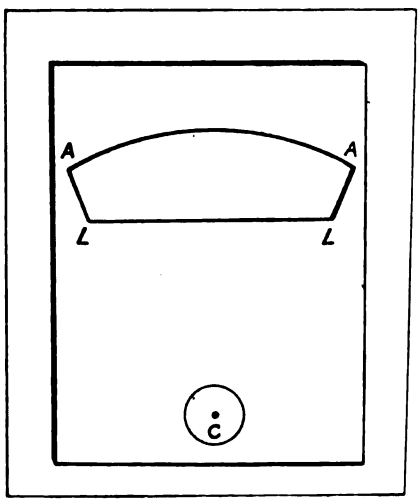

Fig. 5.
Showing ebonite panel with window and hole for ebonite tube.

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winding that the wire does not break; do not put too great a tension on it, for it is hopeless to have to join it. As an alternative a thicker piece of wire about two inches long can be soldered to the end of the fine wire and this can be secured to the pin. Two hundred turns of wire are wound on the former, as evenly as possible, and the outer end of the wire cleaned and soldered to the other pin. With care, quite a neat coil can be made without difficulty, but if the wire breaks it is both quicker and safer to start afresh.

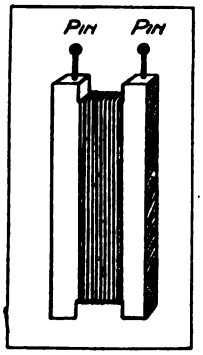

Fig. 6.
Shows coil former, wound, with brass pins for suspension.

Our instrument is now nearing completion. All that remains to be done is to suspend the coil. Consider first Fig. 7, which gives a view of the knob which fits in the top of the ebonite tube, and shows also the 1½ in. brass bolt which passes through the knob. The thread of this bolt which projects through the knob should be filed away, so that a piece of insulating sleeving, "Systoflex," can be forced on so as to cover the brass completely.

Two pieces of 24DCC wire are next tightly bound with thread, as shown, to the insulated bolt, and these two wires form the supports from which the coil and suspension hang, and serve also as conductors by which the instrument is connected to the circuit. The suspension consists of either 47-gauge copper wire or the special phosphor-bronze suspension which can be bought from scientific suppliers.

The suspension, of whatever type, should be first soldered to the pins in the coil former, and having determined the length which will be required the free ends should be soldered to the connecting wires at *WW*, Fig. 7. It is very important that both suspension wires should be of the same length, otherwise the sensitivity of the instrument will be considerably diminished.

Having completed the foregoing operation, the coil is carefully lowered through the ebonite tube, and the connecting wires brought outside the tube for subsequent connection to terminals. The knob is fixed securely into the top of the tube.

A pointer and scale are all that is required to complete the instrument. The scale should be drawn on cardboard, and graduated in any way desired, since the instrument has not yet been calibrated. The pointer is made from thin aluminium foil, or preferably one can employ glass pointers. These are made by drawing out a piece of glass tubing in the Bunsen flame to capillaries. These are extremely light in weight and are about a quarter of a millimetre in diameter. The end should be dipped in ink to render it visible. The best way of attaching the pointer is to make use of a little red wax, sealing wax, shellac or similar material, and the only point to be noted in this connection is that the pointer swings clear of both the cover and the scale.

Note that the instrument is only adapted for direct current measurements, and that it has therefore a positive and negative terminal. This is found by trial. The current from a flash-lamp battery in series with a high resistance should be used for testing; if the pointer swings across the scale, the battery is connected correctly, and the terminals should be marked for future reference. If

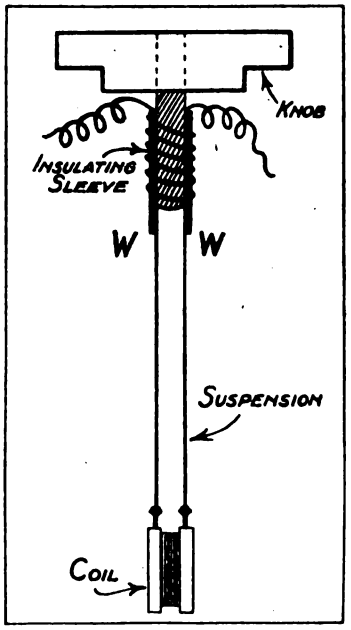

Fig. 7.
Moving coil suspension.

the pointer tries to go the wrong way the battery connections should be reversed.

Calibration of the instrument and the method of adapting it as a "Universal" meter for measuring current and voltage in all ranges will be dealt with in a later article.

Bridging Space.

(*Concluded from page 12.*)

Some form of electrical "valve" or "rectifier" is needed and, as users of broadcast receivers are no doubt aware, this is provided generally in one of two main forms, namely, a combination of two crystals or a crystal and a fine-pointed wire, or, alternatively, through the medium of a thermionic valve connected up in a circuit in a specific manner. One of the accompanying photographs gives three commercial examples of these rectifiers.

The device included must enable the current to pass through in one direction and not in the other, that is to say, its main characteristic must be unilateral conductivity. This feature can best be appreciated by referring to Fig. 3, which gives the characteristic curve of a "Perikon" rectifier, utilising the contact between zincite and chalcopyrite, curve *A*. It will be noted that for positive voltages the curve rises steeply in a positive current direction, but for negative voltages the current rises very slowly in a negative direction and is extremely small when compared with the positive component.

Supposing, then, we apply an alternating voltage to this crystal junction as indicated by curve *B*. When the voltage rises from zero to its maximum positive voltage and back to zero again the current passed through the crystal will resemble somewhat the positive portion of curve *C*. For the same voltage change in the negative direction, however, the negative current will be quite small, as seen in the bottom half of curve *C*.

Rectification.

This process is said to be rectifying the alternating current (it being, of course, remembered that an alternating voltage produces in its own circuit an alternating current), for although there is a small negative current, if we were to take a number of complete voltage cycles instead of the one shown in Fig. 3, the *average* effect (and itis this that influences our telephone receiver, owing to its inherent mechanical inertia) would be a positive current impulse.

As we shall see in our next article, it is the application of this principle that enables the operator to hear signals of a nature identical to those imparted to the microphone at the transmitting studio.

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Television is the Latest of the "Impossibilities"

As WILLIAM J. BRITTAIN'S Facts Show

THAT Baird's disc method can now achieve television of a scene, including full figures of people, is news that the "impossible" has been achieved.

In the early days of the present boom in television many experts said that mechanical means, and especially a disc, never could achieve television.

I went on a tour through the Continent to see what prospect there was of investigators in other countries being first to bring "seeing" to the home.

Dénes von Mihály, who was using oscillating mirrors, told me emphatically that Baird's disc would explode before it achieved a speed fast enough to allow passable transmission of scenes.

Disc apparatus, he said, served only to demonstrate the principle of television, and was satisfactory only so long as one was content with a transmission of 60 to 100 spots of light.

Now he has turned to the disc, and I am informed that it is producing results pleasing to him and to the company formed around his system.

Professor Hans Thirring, of Vienna University, the famous experimenter with selenium cells, was cautious, but inclined to express the same opinion about discs.

He gave me the reprint in German of a long address given by Professor F. Aigner, of the Technical High School, Vienna, which set out to prove that electrical television was impossible.

Professor Max Dieckmann, of Munich, of whom I formed a high opinion as a sincere and able research engineer, told me that he had scrapped his mirror apparatus because he had come to the conclusion that mechanism never could achieve television. Success has not yet met his efforts to harness cathode rays for television transmission.

Pronouncements on the impossibility of mechanical television by such physicists as Sir Oliver Lodge have been frequent. Mr. A. A. Campbell Swinton has expressed to me the opinion:

"It seems very doubtful whether it is possible, by mechanical means, to obtain any much better results than those shown in America at vast expense with very elaborate and complicated high-speed running apparatus, and it has therefore now for a long time been thought and suggested that something better than mechanical methods should be employed."

I have expressed similar opinions myself. I could not see how a holed disc could achieve television of a scene. The thing seemed impossible.

Of course, the disc has not yet vindicated itself completely. It has televised a small scene, but it has yet to show to the public what the public has long expected—a horse race or a boat race scene at home.

There is no reason why the disc should not do this, now that it has travelled so far and so swiftly along the road of impossibility.

If we accept relativity we must believe that one velocity added to another gives the original velocity as total. We must not talk about impossibilities; it may be that our senses are not acute enough to see why a thing can happen.

There have been many occasions when science has declared impossible what has later come to pass. Werner Siemens, the inventor and scientific discoverer, and founder of the great electrical firms bearing his name, said that it was impossible to fly by machines heavier than air. And Helmholtz proved it mathematically!

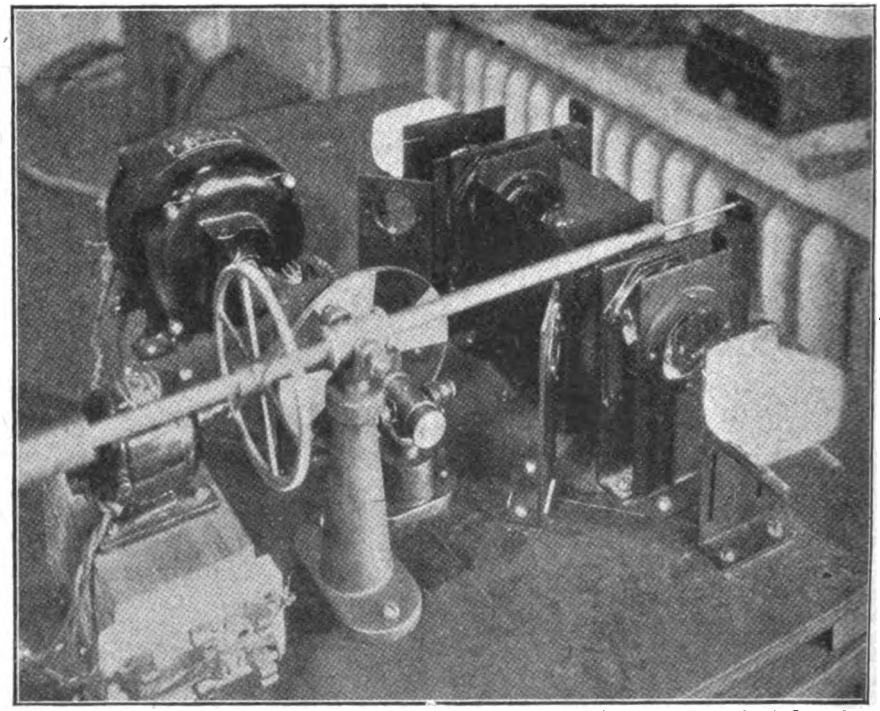
Scientific experts here laughed, and accused the Wright brothers of trying a hoax when they reported that they had flown.

Many a learned man said that the locomotive was impossible, and both Stephenson and Riggenbach were accused of craziness.

Babinet, the physicist, showed by mathematics that it was foolish to dream of a telegraphic cable between Europe and America.

Experiments of Philipp Reis, which might have led to the telephone, were nipped in the bud by the pronouncement of the famous physicist Poggendoff that the project was impossible. The "Impossible!" continued even when Graham Bell had produced his telephone.

While I know that Baird does not need these precedents to give him courage, they may bring a little meekness to those stalwarts who are still holding their hands over their eyes and crying "Impossible!"



[Photo by courtesy of G.E.C., U.S.A.

A close-up view of the recording spectro-photometer referred to on page 27.

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The Story of Chemistry

Part VI

More Relationships

By W. F. F. SHEARCROFT, B.Sc., A.I.C.

HAVING introduced ourselves to the element family, the acid family, and the oxide family, we can now pass to the family of bases, which, briefly, may be considered as the opposites of the acids.

There is considerable confusion over this group, for the word *base* and the adjective *basic* are used with more than one meaning. This does not lead to misunderstanding to the chemist familiar with the substances concerned, but it certainly does do so with those less familiar.

For our purposes in these articles we will restrict the use of the word *base* to those substances which are properly called *hydroxides* of the metals. A simple example will help—sodium hydroxide is a typical base. It has the formula $NaOH$, in which we see the single atom of sodium connected up to a group of two atoms, which are frequently associated together and are called the *hydroxyl group* (OH).

Oxygen we recall has two valencies, and hydrogen one, and so we get a picture of the hydroxyl group thus: $-O-H$.

Here we see that there is one *free* valency, and therefore it is impossible for the hydroxyl group to have a separate existence. It is always found associated with something else, and when this something else is a metal then the molecule formed is a molecule of a base. In the formation of the molecule there will be one hydroxyl group for every valency possessed by the metallic atom.

Examples of other bases are given below:—

Copper hydroxide	$Cu\begin{cases}OH\\OH\end{cases}$ or $Cu(OH)_2$.
Calcium Hydroxide	$Ca\begin{cases}OH\\OH\end{cases}$ or $Ca(OH)_2$.
Potassium hydroxide	KOH
Zinc hydroxide	$Zn(OH)_2$.
Iron hydroxide	$Fe(OH)_3$.

Examining these examples we can construct a general formula thus: $M.OH$, where M stands for a metal atom. (There are some people who always write the formulæ of bases thus: $M.HO$). There is a group of atoms called the *ammonium group*, which have the formula NH_4, but have no separate existence. They are capable of acting as if they were a metal. This group joins up with an hydroxyl group to form the molecule $NH_4.OH$, called *ammonium hydroxide*, which behaves in all respects as a metallic hydroxide—that is, as a base.

THIS is the sixth of our contributor's articles on the story of chemistry, written in simple language, with the introduction only of those chemical formulæ as are essential to an understanding of the subject. Last month he dealt with chemical families. This month he continues by giving us details of further chemical relationships, and explains the mysteries of salts and how they are formed.

Having stated what bases are, we can now see how they behave. Most of them are powders which are insoluble in water, or only very slightly soluble. Slaked lime is an example, familiar to everybody. It is calcium hydroxide $(Ca(OH)_2)$. When strongly heated they usually lose water and leave the oxide behind; thus, for example, when slaked lime is heated we get quick lime, which is calcium oxide.

$$Ca(OH)_2 \longrightarrow CaO + H_2O.$$

Those which are soluble in water give a solution which is *alkaline*. Such a solution has a soapy feel and turns red litmus blue, and has a caustic action on animal or vegetable tissue.

The most important property of the bases is that when mixed with an acid the process we call *neutralisation* takes place. In this action both the acid and the base lose their characteristics. This is the most important action with which we shall have to deal, and so we will try to make it very clear by a concrete example.

Let us take as our example of an acid the solution which is called hydrochloric acid. It is a colourless liquid which fumes in the air, has a very sour taste, and will corrode our skin or our clothes. It produces very bad sores on the hands, and if we drank it we should very soon die in awful agony. This substance has the formula HCl.

As our base we will select caustic soda, or, to give it its proper chemical name, sodium hydroxide $(NaOH)$. This is a white solid, which deliquesces—that is, absorbs water from the atmosphere, and so must be kept in tightly stoppered bottles. It is easily soluble in water, giving a solution which has a caustic taste, is very corrosive, and turns red litmus blue. Again, if we drank the solution, we should quench for ever the best thirst imaginable.

Into some convenient vessel we will put a little of the acid solution, and add a few drops of litmus, which will colour the solution red. Now slowly, and a little at a time, we will add the solution of caustic soda, and stir the mixture well after each addition. Nothing visible occurs at first, but after a time we note that the red colour seems a little less red, and a stage will come where the colour is neither red nor blue, but a kind of in-between, port wine colour.

Now we know that the acid would

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turn the litmus red, and the base solution would turn it blue, but in this mixture of both acid and base neither colour changes are occurring. Whatever there is present, neither acid nor base can be there. Actually if you carry out this experiment—and be careful that you have arrived at this neutral state—you can now pick up the vessel and drink the contents with safety! You will immediately recognise that you are tasting salty water.

If we go a step further and boil this final mixture, then the water will boil away and we shall get a residue which is a white crystalline powder, and can be recognised as the ordinary common salt which we use to season our food. Here is a most wonderful change, and something similar occurs when we mix any acid with any base in the quantities required for neutralisation. We may write in general that:

base+acid⟶salt+water.

We must not make the mistake of supposing that any acid and base will give us common table salt. The word *salt* in chemistry is given to a class of substances, which are, in general, crystalline substances, and they can be made by this process of neutralisation of the appropriate acid with the appropriate base. Let us put this reaction into general symbols:

$M.OH+H.R\rightarrow salt+H.OH$,

and an examination of this will indicate that the general formula for a salt is *M.R.* A salt is formed by taking the metal from a base and combining it with the acid radicle from an acid, and this gives us,

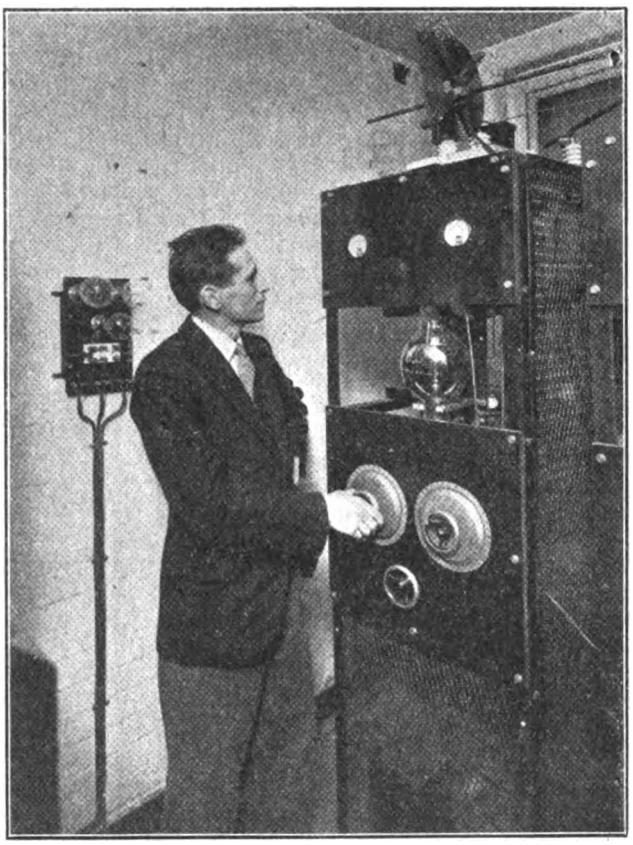
$M.OH+H.R\longrightarrow M.R+H.OH.$

Converting this into the particular case with which we dealt we get:

$Na.OH+H.Cl\longrightarrow NaCl+H.OH.$

The formula for table salt is $NaCl$, and the formal name is *sodium chloride.* All salts are named in this way. The name of the metal comes first, and the name of the acid radicle comes next. Thus *sodium sulphate* is the salt made from the metal out of sodium hydroxide, the base, and the radicle out of sulphuric acid, which is called the *sulphate radicle* (SO_4).

(Dating back almost a century there still remains the echoes of another method of naming salts in which the name of the acid radicle comes first, thus: chloride of sodium, sulphate of sodium. There is little chance of making a mistake here, but there is also a still more objectionable method used in everyday life and in commerce, such as the well-known substance which you buy from the druggist's shop as *carbonate of soda.* Now, actually, this is a salt, and its proper name is *sodium carbonate*, which tells you what it is. Fortunately these archaic expressions are dying out, and the only way to deal with them is to refer in all doubtful cases to a list of common names and their chemical equivalents.)



A hitherto unpublished photograph of the new wireless television transmitter, which is situated on the roof of the Baird Laboratories in Long Acre.

In the table below is given a list of the common acids, and the formulæ and name of their radicles. This should enable us to give a name to the formulæ of any salt which we come across.

Acid.	*Formula.*	*Radicle.**	*Salts are*
Hydrochloric	HCl	$(Cl)^{-}$	Chlorides.
Sulphuric	H_2SO_4	$(SO_4)^{=}$	Sulphates.
Sulphurous	H_2SO_3	$(SO_3)^{=}$	Sulphites.
Nitric	HNO_3	$(NO_3)^{-}$	Nitrates.
Nitrous	HNO_2	$(NO_2)^{-}$	Nitrites.
Carbonic	H_2CO_3	$(CO_3)^{=}$	Carbonates.
Hydrosulphuric	H_2S	$(S)^{=}$	Sulphides
Phosphoric	H_3PO_4	$(PO_4)^{\equiv}$	Phosphates.
Phosphorous	H_3PO_3	$(PO_3)^{\equiv}$	Phosphites.
Hypochlorous	$HClO$	$(ClO)^{-}$	Hypochlorites.
Acetic	$H(C_2H_3O)$	$(C_2H_3O)^{-}$	Acetates.

* The radicles are written in parentheses to suggest that they have no separate existence.

For example, what are we to make of this: $Pb(NO_3)_2$? First, we must recognise it as a salt. The formula starts off with *Pb*, which we find is the symbol of the metal lead. Whatever the substance is, it will be lead "something." In the rest of the formula we spot the group (NO_3). It does not matter that the formula gives two of these groups. (NO_3) we recognise as the radicle of nitric acid, the nitrate radicle, and hence the substance is the salt, lead nitrate.

Now we may ask, why are there two nitrate groups in the formula for lead nitrate? In nitric acid the nitrate radicle is attached to one hydrogen atom, thus: $H-(NO_3)$. Therefore, when the molecule is torn apart, the nitrate radicle will have one free valency with which to hook on to metal atoms. The lead atom has two valencies, and so it will require two nitrate radicles to satisfy it, which can be represented thus:

$$Pb<^{(NO_3)}_{(NO_3)}$$

or in the more usual manner, $Pb(NO_3)_2$. In the table above it will be noticed that to each radicle little dashes have been added, and these represent the valency of the radicle. Knowing the valency of any metal atom, we can write correctly the formula of any salt. It must once more be stressed that these tricks, as it were, are only possible as the result of the research work that has been done in the past on the substances concerned.

You will come across salts in the pages of TELEVISION which are not included in the tables given here. This is not a text-book, but a series of semi-popular articles, and it is only possible to deal with simple things.

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Light: The Essential of Television
Part VII.

By CYRIL SYLVESTER, A.M.I.E.E., A.M.I.Mech.E.

Light is one of the most important factors in connection with television, and one which must be carefully studied by all serious students of television. The principles and nature of light are by no means so widely known and understood as one would anticipate, and in this series of articles our contributor is elaborating them month by month.

IN a scene which contains objects with high reflection factors, considerable care must be taken when choosing positions for, and the intensity of, artificial lighting units.

Let us consider the case of a lighting unit of the semi-dispersive type which, by calculation, is considered suitable to illuminate an object, with the correct amount of light and shade to a certain intensity. If other bodies round this object have high reflection factors light is reflected from them on to the object at different angles to that of the unit with which it is intended to illuminate the object. The effect of this is that the shadows are not so dense, or emphasised, so that the object appears to lose shape.

An example of this can be seen in any school room where wooden objects, painted white, are used for model drawing. The light upon these objects must be directional. The objects are placed upon a blackboard laid on the floor in such a position that light from the windows is projected upon them in a definite direction. The blackboard absorbs the whole of the light incident upon it, so that no light is reflected in an upward direction. If the walls of the room are light, then a certain amount of light will be reflected from them on to the models. This light is much lower in intensity than the daylight, according to the reflection factor of the walls, but it is not sufficiently intense to destroy the shadows completely. Where two models are almost touching, at a point between them, where they are not obtaining direct light, the shape of the objects will appear to be different. I have seen an hexagon appear as a cylinder, the sides of the former appearing to be perfectly flat.

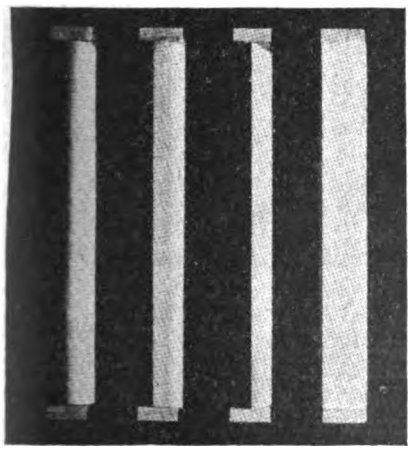

Fig. 1.

Effect on Shape.

But light, especially of an artificial character, must not be too directional, or here again the objects will appear to lose their shape. This is illustrated in Figs. 1 and 2. The photographs from which these illustrations were reproduced were taken some time ago when I was investigating the effect of various kinds of light upon objects as seen by the eye or the camera. Four objects of wood of different shapes were placed in a box which was equipped with lighting units in such a manner that light could be projected upon them from certain directions.

In Fig. 1 light of high intensity was projected upon them from a unit located at the right-bottom side of the box. The inside of the box was painted dead black. The effect is that the first object, a cylinder, is

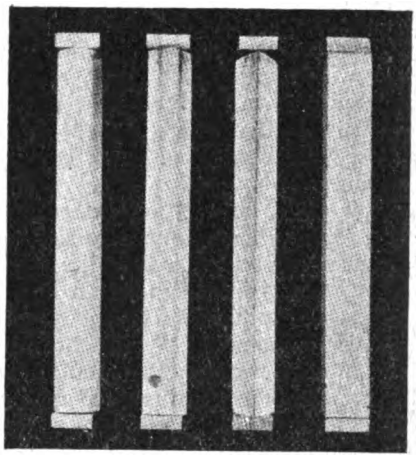

Fig. 2.

half obscured in shadow; its shape can just be seen by consideration of the top and bottom. The second object is an hexagon; it cannot be seen whether the portion on the left follows the same contour as that on the right. That is, it may be just half a hexagon from what can be seen of it.

The third object is square with the corner pointer to the observer; here, again, the shape of half of it is entirely lost. The fourth object is also square, with one face towards the observer. This is, as is to be expected, flat. If the interior of the box had been painted, say, dark grey, a certain amount of light would have been reflected back on to the objects so that they would appear to have definite shape, from which it will be seen that, although direct light in this case conceals the shape of the objects diffused light assists in revealing them in their true perspective.

In Fig. 2, which illustrates the same objects, but under different

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conditions of illumination, the shape of the objects can readily be seen. The transference of the shadow on the cylinder from one side to the other should be noted; this was inevitable,

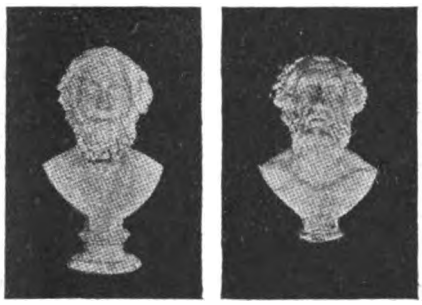

Fig. 3.

because a lighting unit was fitted in the box at a point opposite to that of the first one. The intensity of this unit was higher than that of the first one; if it had been lower, the intensity on the square piece of wood would have been too low for correct illumination.

Figs. 3, 4, and 5 are interesting since they illustrate the effect of various kinds and degrees of illumination upon a plaster figure. In Fig. 3 (left) the illumination is of a dispersive character; it is obtained from a number of units located round the object. One can just see that the object is a bust of a man with a beard. Faint lines indicate the positions of the nose and mouth, but on the face, in general, is expressionless. In this same illustration (right) the light is diffused, but of a directional character; it is projected from below the object, but slightly from the front. The units had a narrow angle of cut-off, this resulting in cutting the base of the bust off completely. It can be seen, however, that the face has assumed some expression; the mouth is more clear and the nose has taken shape. It is a better effort of illumination than the first one, but it is not good by any means.

Lighting from Above.

The method adopted to illuminate the object in Fig. 4 (left) has certainly had the effect of making some of the features more prominent. When this photograph was taken a number of lamps in clear bulbs were accommodated in mirror glass reflectors; they were located above, but just in front of, the object. The effect is a dense shadow below the head and hard shadows round the mouth and nose. Let us consider for a moment the effect of fitting lighting units of the same kind below the object, in an effort to eliminate the shadows.

The shadows would be less dense by fitting units of the same intensity, with light in the same direction; they would not, however, be entirely eliminated. The effect would be to reduce the density of the shadow on the chest of the bust, but slight shadows would appear on the lower part of the mouth and the upper portion of the nose. The general effect would be something like that illustrated in Fig. 3 (right) with the lines emphasised.

In Fig. 4 (right) the same lighting units were used as for the left illustration; they were located slightly above and to the left of the object. The result is a dense shadow on the right of the object which completely obliterates some of the features. The face appears altered in expression. So much so that it may be said that,

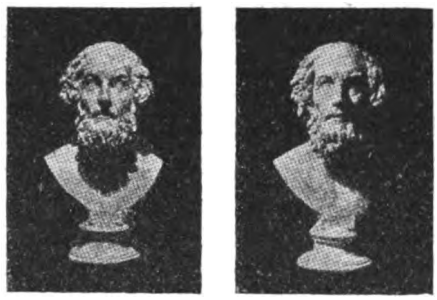

Fig. 4.

if the two illustrations were not closely compared, it may be considered that the objects are not the same. In Fig. 5 (left) the lamps were accommodated in dispersive type reflectors and their location was altered slightly; they were placed a little more to the front. The expression on the features is destroyed which, at first thought, may be considered as a step in the wrong direction. This is not so, as will be seen from the following considerations.

The shadow has been moved round the object so that more of the latter can be seen. The features on the left are not too clear; the lines need to be more emphasised. The illumination at the base of the head appears to be correct, so that it is merely a question of reducing the remaining shadow and increasing the shadow which will give tone to the lines on the face.

This effect is shown in Fig. 5 (right). The eyes can be clearly seen, the nose has shape, the features of the face are symmetrical, and there is just sufficient shadow at the bottom of the head to make the latter "stand out" from the chest of the bust. The illumination was produced by dispersive type units placed at the bottom and top of the object. The intensity of light in the downward direction was higher than that in the upward direction; hence the soft shadow on the chest. The lamps were clear ones and they were accommodated in reflectors of the concentrating type. The latter produces illumination of a directional character, although it is dispersive.

Purpose of a Reflector.

I have previously pointed out that the object of a reflector is to collect the whole of the light rays from an electric lamp and direct them in any desired direction. The effect of light projected from a reflector depends in no small measure upon its distribution. By the term distribution it is meant that a reflector fitted at a certain height above an object will illuminate objects within a certain area. If the lamp in the reflector is decreased in candle power the area illuminated will be the same (providing the lamp filament centres are the same) although the intensity will be less.

All dispersive type reflectors of the circular type produce an illuminated area in the form of a circle or disc; this is only true when the plane to be illuminated is at right angles to the direction of the beam. Let us assume, for instance, that a dispersive type unit is located above the centre of a stage. The illumination on the floor will be in the form of a circle. If, however, light is projected upon

Fig. 5.

the stage from a "front of the house" spotlight the beam will be elliptical.

This factor has to be considered in the illumination of settings. Let us assume that a number of dispersive

(*Continued on page 22.*)

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Sydney A. Moseley

ON

"AT LAST!"

IT doesn't seem so long ago since I began my campaign in this journal for the broadcasting of television in this country. All I asked for—and asked repeatedly!—was a fair trial for television.

That was all.

Lately readers may have noticed the note of optimism that has crept in my articles. I had reason for it. Although I was unable to make public everything I knew, I gave as many broad hints as were possible, without breaking a pledge of secrecy to which we were all held.

Well—at last! I was not permitted to say a word about it. And now both the Postmaster-General and the President of the Board of Trade have let the cat out of the bag!

Both the B.B.C. and Bairds kept strictly to their arrangement to say nothing about the tests; but obviously questions in Parliament have to be answered straightforwardly, and the P.M.G. had no other recourse but to tell the ever-increasing number of members interested in the subject that at long last television was to be properly tested by broadcasting.

A red-letter day for all those who had faith in this big thing.

How did it all happen? For the benefit of future historians let me set down the facts.

After the Post Office engineers had witnessed a demonstration at the Baird studios in Long Acre the Postmaster-General wrote saying that he now had no objection to the use of a broadcasting station for experimental purposes, subject to suitable conditions, etc. What it all amounted to was that the Post Office engineers had O.K.'d television and that, so far as they were concerned, experimental broadcasting of television might begin right away.

Now came the snag. The existing broadcasting stations were in the hands of our friends the B.B.C., and we were referred to them for the purpose of making the necessary arrangements and terms.

IN the course of an answer to a question in the House of Commons recently, the Postmaster-General said: "... so far as my Department is concerned, I should be prepared to agree to the use, subject to suitable conditions, of one of the B.B.C. stations for experiments with television apparatus. ... A further demonstration is being arranged, after which the question of using a broadcasting station for television will be reconsidered."

What happened afterwards readers well know. The technical people of Savoy Hill did not see eye to eye with the Post Office engineers. And we were left to stew! Recollect, however, that the B.B.C. added a paragraph to their communiqué (in which they stated their inability to grant the Baird Company the use of a B.B.C. station) that *they would be prepared to reconsider the matter as soon as television improved!* Apparently news soon reached Savoy Hill from many quarters that it had. There came to the Baird studios, as I told readers, many distinguished public men and women. They beheld, and saw it was good. And one and all told Sir William Mitchell Thomson about it.

I may now reveal one more little secret since it rebounds to the credit of the Postmaster-General. According to the *People, he came himself with Viscount Wolmer, his assistant, to find out the truth about television.* A friend of mine who was present at the demonstration told me that both the chief and his first lieutenant were vastly interested. Next came Mr. Ammon, M.P., for many years associated with the Post Office. He made no secret of the fact that he was agreeably surprised to find that television had advanced far more rapidly than he had imagined. He was particularly concerned lest Germany broadcast television before we did. My friend, Bob Williams, the great Trade Unionist, wrote "Marvellous"

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in the visitors' book after he had seen it. He did more; he wrote to Ramsay MacDonald about it, just as another eminent publicist wrote to Mr. Baldwin.

To do the B.B.C. justice, when these reports reached them, they sat up and took notice. Either television had suddenly improved or—well, it had been judged by its representatives rather within the too narrow "technical" limits.

"If the present state of television interests so many people, the fair thing to do" (they must have said) "is for us to give experimental transmissions from 2LO or from 5XX. Then if a jury of disinterested members of Parliament find it as interesting at Savoy Hill as everybody seems to have found it at the Baird studios, we can give it a trial run—and then we can tackle the technical problem, if any."

So it is that for the first time in history the *heads* of the B.B.C. and the Baird Company have come together in the friendliest possible manner.

Now that is all I have demanded. I am certain that, providing normal transmissions are assured, it will be shown that television in England has reached a commercial state. And the prospects are that after all *England will be the first country to give a regular transmission of the British system of television*. It will be a near thing, however. Both France and Germany were neck to neck in the race to be the first country to broadcast the Baird system.

Engineers have left the studio in Long Acre for Berlin as I pen these lines. They have gone to Germany at the invitation of the wireless authorities to take measurements for the installation of the first Baird television transmitters.

At the same time the French group of wireless experts were so delighted at what they saw in London that an enticing offer was made to the Baird Company for the control of television on the Continent.

Altogether, then, things are beginning to hum in earnest. Admittedly we are not entirely out of the wood yet, and I do not wish to shout prematurely. But it has been a wonderful fight to obtain and maintain the recognition and the right of the only British system of television.

It is but a few months since I approached mutual friends at Savoy Hill to try to establish unofficial liaison between the B.B.C. and Baird television. Through many vicissitudes I have at least succeeded. For an outside interpretation of what has happened I will ask you to turn to the article by "A Student of Progress," a pen name which hides the identity of an eminent independent patron of scientific development.

Memories of recent strife are still too bitter within me to permit me to go the full distance with this writer in his explanation of B.B.C. policy and attitude. Moreover, I think he should have had something to say about the determination, fortitude, and patience of my friends Baird and Hutchinson. But with these reservations I am with him all the way, and hope he will continue to help forward the task of ushering in the era of television.

Light: The Essential of Television

(*Concluded from page* 20.)

type units are fitted to illuminate a setting. The illumination may be fairly even, but it is not completely so. This is because, assuming the edges of the beams to be touching, there will be a space upon which no light is projected. This space is illuminated only by virtue of the fact that objects in the vicinity have greater or less reflection factors. With even illumination of a dispersive character the true effect of light and shade is impossible. From this it will be seen that, in addition to what may be termed general illumination, the light projected upon a setting must also be directional.

By this I am not suggesting that objects should be flooded with directional light as illustrated in Figs. 4 and 5; the necessary effect may be produced by projecting light of high intensity upon a white sheet from which it is re-directed on to the objects which it is desired to illuminate. If it is necessary to project direct light upon a setting care should be taken to ensure that none of it is reflected back on to the opposite side of the object. The way to provide against this is to fit screens, just off the stage, which have a zero reflection factor; in this way the light incident upon them is absorbed.

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A SIMPLE SHADOWGRAPH TRANSMITTER

By E. V. R. MARTIN

Since we described how to make a simple televisor in our first three issues a large number of experimenters have written to us describing the results which they have obtained, and enclosing photographs of their apparatus. One of the best descriptions is that given in the following article by Mr. Martin, who very successfully demonstrated his apparatus on January 15th in the course of a lecture on television at the Midland Institute, Derby, before the Derby L.M.S. Railway Wireless Club.

THE principles involved in the construction of a machine to transmit the shadow of an object are fundamentally the same as those required for television, but there is the advantage that the method is much more easy to demonstrate, and the cost need not be so great.

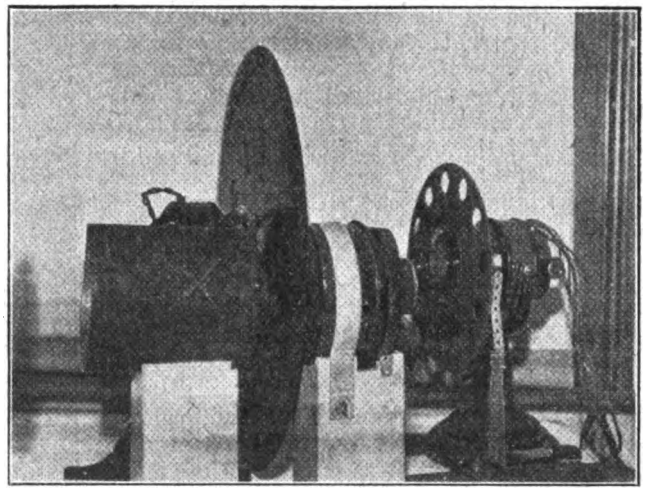
Although the available literature on the subject is only small in amount it is possible by reading the patents columns in electrical journals to get a variety of ideas for experimental work.

The apparatus described has been very successful and has well repaid the time expended upon it, although it has now been scrapped to make room for a more ambitious projector. In order to keep the details together the instrument is divided into three sections — the transmitter, the receiver, and the amplifier; these will be described in that order.

The Transmitter.

The first part of the machine to be constructed was the optical bench, and is a system of lenses and light source mounted on a long, narrow board. A narrow base is used so that the driving motors for the discs can be easily adjusted to the correct distances relative to the lenses and the selenium cell. The source of light is a 200-watt gas-filled electric lamp which is mounted in a sheet-metal shield at the extreme end of the base board in order to give ample room for focussing. There are three lenses in the system which were found to be necessary to get a good image of the lamp filament on the face of the selenium.

A 5½-inch condenser was purchased and experiments were tried with it complete in its housing, but it was soon apparent that to get the image to stay on the cell the scanning disc must rotate between the lenses of the condenser. It was therefore cut in half and each lens mounted separately on a hollow wooden block so that they could move to and fro on the base until proper focussing was achieved.



A view of the transmitter.

An uncoated selenium cell was fixed at the other end of the board and the lamp filament image focussed upon it. An extra lens was then mounted just in front of the selenium to further reduce the amount of picture which was outside the active area on the face of the cell. The selenium cell itself was mounted on a bracket which ran in grooves in order to get final adjustments with the scanning discs in place. The cell was also readily detachable as a duplicate had to be interchanged when one failed.

The selenium cell is probably better purchased from a reliable source. The two cells the writer had both broke down with a potential of only twenty volts. They were recoated with powdered selenium, which was stirred about the face of the cell when hot enough to melt. A lot of time was spent on coating the cells as more often than not a cell which was good one day had gone wrong the next.

Cells are best kept in the dark and in such a position that damp cannot condense on the back of the condenser plate edges. The most successful coatings were obtained by cutting off the heat when the powder melted and stirring the mass with a pointed glass rod until an even covering was obtained, the surplus was removed with the side of the rod and stirring continued till crystallisation set in. When the first crystals appear do not touch the cell again and a good crystalline film gradually covers the surface.

The Scanning Discs.

The diameter of these was decided by the motors available at the time, and was fixed at 20 inches. The size of picture was intended to be around 3 inches by 2 inches, and the holes were drilled accordingly. These are

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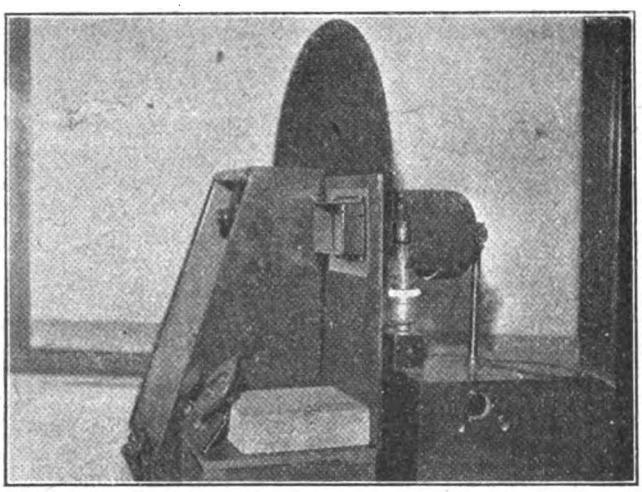


The receiver, showing speed control rheostat in foreground.

twenty-four in number and were marked out on the sheet tin discs with a sharp point. First 24 radii are marked out at equal distances. Then ½ inch from the edge of one of these a mark is lightly made with a centre-punch. This point represents the first of the spiral of holes. On the next radius a point is marked which is ⅛ inch nearer the centre than the previous one, and so on with the remainder of the radii until all are marked.

All the points are drilled with an ⅛ inch drill and the burrs carefully removed from the holes. No attempt has been made to make the holes square or segmented. The centre hole is enlarged to take the motor spindle bushing and the whole disc is painted dead black.

The driving motor for the scanning disc is a 200-volt 50-cycle induction motor with squirrel cage rotor. Single wound field, that is; no starting winding. This motor at the zenith of its career drove a fan, but the blades having been removed the scanning disc was easily fitted to the spider which remained. A simple series resistance controlled the speed from about 100 to 2,000 revs.

At the higher speeds the whole thing vibrated badly owing to the disc being out of balance. Small balance weights were therefore bolted at a suitable position on the rim.

The Interrupter Disc.

Various experiments were tried with cardboard discs and the final arrangement was 10 inches diameter, with twelve holes each of sufficient size to expose the full face of the selenium cell. This disc was mounted on the shaft of another fan motor, a D.C. machine being used on this occasion. A series resistance controlled the speed and the motor was operated on the A.C. mains.

The whole transmitter can be assembled very simply by sliding the scanning disc in between the two condenser lenses until the rotation of the disc produces an image on the cell face which does not wander off at the commencement and finish of the scanning operation.

In order that no two holes were in action at one time a cardboard cover was made for the lens nearest the light source, which only allowed an area 3 inches by 2 inches to be illuminated.

After carefully adjusting the position of the cell the interrupter disc is placed just in front of it, so that the holes will allow proper illumination to take place.

The Receiver.

This is really a very simple piece of apparatus. It consists of a scanning disc, exactly the same as the one at the transmitter, mounted on the shaft of a 200-volt D.C. motor which has a variable resistance in series with it for accelerating and decelerating the disc when "fishing" for the image. The motor and disc are suitably mounted on a wooden framework on one side of which is fixed a support for the reproducing light source, a reflector and the receiving screen.

A G.E.C. Osglim lamp is used, mounted inside an ex-W.D. signalling lamp in such a position that a beam of light approximately parallel is produced on causing the bulb to glow. The receiving disc is placed in this beam as near as possible to the light source. At the other side of the disc the receiving screen 3 inches by 2 inches is fixed at the proper height and distance from the centre to be correctly scanned by the spiral of holes in the disc. This screen is placed as near to the disc as possible without contact on rotation. As both discs were found to be slightly buckled after the drilling operations it is not possible to get much nearer than ⅛ inch.

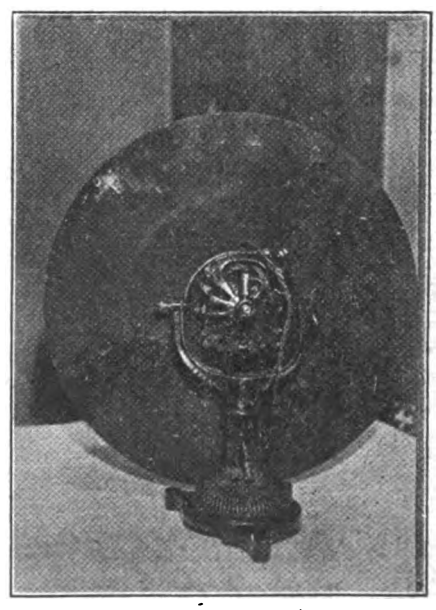
The Amplifier.

If any success is to be achieved in serious experimental work on television a really good amplifier is essential. In the writer's opinion the output stage of the amplifier should be capable of dissipating a minimum of 25 watts in order to get proper response on the weaker portions of the transmitted signal.

The equipment used is complete in itself and only requires connection to the 200-volt A.C. lighting mains.

The power-supply unit consists of a B.T.H. mains transformer delivering 1,200 volts, 150 m.a. on a centre-tapped winding, also 7½ volts centre-tapped for heating the filaments of the R.H.1 rectifying valves. Another 7½-volt winding serves to heat the filaments of the B.12 power valves. There are two previous stages both transformer coupled, the valves being two Metro-Vick A.C.G. with 4-volt separately heated filaments or cathodes. These heaters are connected in series across the B.12's.

The high pressure winding is fed to the R.H.1 valves and full wave rectified into 600 volts D.C. This is smoothed by a 6 mfd. condenser tested to 1,500 volts, together with a smaller 6 mfd. condenser and several of 2 mfds. The smoothing choke is the 100-volt magnet pot of a Rice Kellogg loud speaker, which, in addition to smoothing the supply and exciting the speaker is made to provide the necessary 100 volts or so to grid bias the B.12 valves. The connections are clearly indicated in



One of the scanning discs and driving motor.

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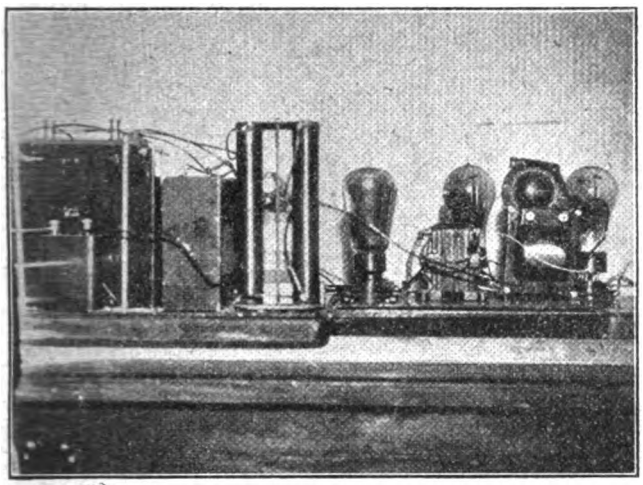


A view of the amplifier.

the diagram, and are protected under B.T.H. Patent 294250, July 22nd, 1927 (U.S.A.).

The full circuit of the amplifier is also given. There are several methods possible of getting the energy in the last valves to light the neon lamps. The usual system of the lamp in series with the H.T. supply was not considered practicable. For one thing, the B.12's are run with 475 volts on their anodes at a current density of 30 milliamps per valve, and the biasing arrangements to persuade the lamp to go out when no signals were being received would be troublesome; again, the operator might easily receive a severe, if not fatal, shock supposing he came into contact accidentally with the neon lamp. To avoid unpopularity on this score it was decided to try a choke and condenser feed to the lamp, but the response was not sharp enough.

A special output transformer was then made up with an air gap of $\frac{1}{8}$ inch and a ratio of one to one. This gave very much brighter signals and better response when no object was being transmitted, but was not quite good enough when the light rays reaching the selenium were further cut down by the presence of the object. This difficulty was finally disposed of by making use of the known ionising potential of the neon lamp.

If a dry H.T. battery is connected in series with the lamp and the voltage gradually increased from 70 to 150 or so a point will be found at which the lamp just commences to glow. This is in the neighbourhood of 140 volts, and further increments of voltage cause the brilliancy of the lamp to increase step by step. Care should be taken when carrying out tests of this nature as the current rapidly increases as the voltage rises and the lamp eventually flashes over. This applies only to the special lamps sold for television which have had their series ballast resistances omitted.

Good response and brilliancy were secured finally by biasing the Osglim lamp with a 99-volt dry battery in series with the secondary of the output transformer.

Instability of the Amplifier.

Most experimenters have met this difficulty which usually manifests itself as a continuous glow in the neon lamp, usually accompanied by a very high pitched whistle from the output choke or transformer.

This is easily overcome by the judicious use of lead-covered cable in places where reactions are likely to occur. The writer has persistently urged the use of lead-covered wire for amplifier connections, both internal and external. The advantages of doing so are many and various, but the work is by no means simple.

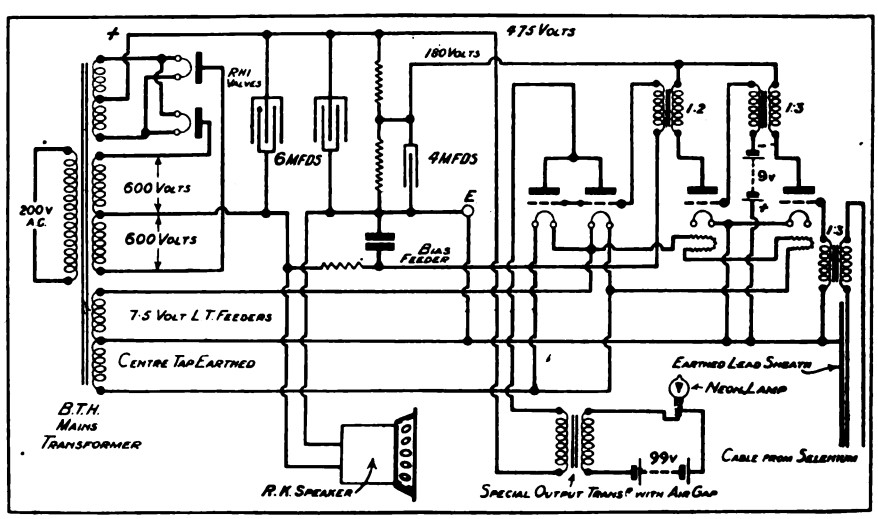
Operating the Apparatus.

The transmitter is set up with all discs properly placed and the selenium cell exposed. The scanning disc motor is started up to some 150 revs. per minute and the interrupter set going at about 800.

A pair of telephones and a 20-volt accumulator are connected in series with the selenium and the light source switched on. If all is correct a characteristic note produced by the holes in the scanning disc is heard, superimposed on which is a higher pitched note from the interrupter. The presence of these notes separately can be tested by stopping one or the other of the motors, leaving the cell aperture open. The signals heard will not be loud, and if accompanied by a fizzing or hissing noise operations should be stopped and the cell tested for silence. If the cell is silent the noise is sparking at the motor brushes, and steps should be taken to remedy it forthwith. It may be necessary to go round all the motor carcases with an earth wire, and of course see that the connections to the selenium cell are lead-covered and that the covering is properly earthed.

A twin lead covered cable is substituted for the phones if the selenium is responding properly, and the distant end is connected to the input of the amplifier.

The 200-volt supply is switched on to the amplifier and the neon lamp should begin to glow. It is probable there will be a slight flickering of fairly rapid frequency observed. If the hand or a pencil or a cardboard letter is placed in the beam of light coming through the 3 inches by 2 inches opening cut in the cardboard cover of the lens, the neon lamp will be observed to flicker in a different manner characteristic of the separate objects. If the beam of light is entirely obscured the lamp should cease to glow.



Complete circuit diagram.

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Having got thus far the real entertainment begins. Assuming the receiving apparatus is correctly assembled and the neon lamp in place in its reflector, the motor driving the scanning disc may be started. The transmitter should be working without any object being placed in the frame. As the speed of the disc increases at the receiving end the single spot of orange-coloured light which is visible on the screen forms into lines and irregular patterns strongly reminiscent of the stroboscopic experiments of one's early youth! As the speed approaches synchronism with the transmitter the whole screen becomes evenly illuminated with a somewhat coarse grain. When this condition is reached an attempt may be made to send a shadow of an object or a stencil cut from card.

The stencil is placed in the 3 inches by 2 inches aperture at the transmitter and the operator at the receiver endeavours to get the receiving disc absolutely in step with that of the transmitter. At first the process is somewhat difficult, but by accelerating the disc and allowing the speed to come down slowly it is possible to use the stud switch on the resistance to keep fairly good synchronism.

By noticing the doubling up of the images and their apparent direction of motion (either progression or retrogression with respect to the direction of the disc's rotation) it soon becomes an easy matter to drop on the right speed.

Alteration of the speed of both discs to a higher rate of revolutions improves the images considerably, and if the screen is crossed by slowly moving black patches or lines an acceleration of the interrupter disc is indicated.

Without the aid of special synchronising devices extremely good shadows have been transmitted via a length of twin L.C. cable, but some simple form of synchronising motor is a great help, although this means an extra conductor for the impulse.

A projecting stud was mounted on the back of the transmitter disc which made contact once per revolution with a brass spring. At the receiving disc a horizontal armature was attached at the centre lying equally along a diameter. Facing this was mounted a laminated electromagnet excited from a 60-volt dry battery so connected to be magnetised when the contact was made at the transmitter.

The position as regards phase between the stud on the transmitter and the armature on the receiver was carefully chosen to hold the disc in step with the picture reasonably central on the screen. This remarkably crude device was a huge success, but had to be scrapped because the mortality amongst the H.T. batteries was somewhat high, and also the impulse on breaking the field of the magnet insisted on operating the amplifier and smudged the picture in spite of several microfarads across the contact.

The photographs show the transmitter, receiver, amplifier, and the transmitter scanning disc by itself.

In the photograph of the transmitter can be seen the 6-inch diameter copper tube containing the first condenser lens, the scanning disc, and then the second lens mounted in its original housing. It should be mentioned that the two flat faces of these lenses are together.

On the same mounting is the small extra lens which further concentrates the beam from the light source on to the selenium cell. The Meccano strip bracket supports the selenium cell which is not shown. This bracket slides along grooves in a steel plate for final focusing. In front of this can be seen the edge of the interrupter disc with its circular holes. All connecting wires and motor speed controls have been omitted for the sake of clearness.

The receiver photograph shows the motor framework, gelatine screen, neon lamps, and reflector. The synchronising control resistance can be seen in the foreground.

The amplifier output stage has two valves in parallel, but only one can be seen in the photograph as they are arranged behind each other.

Death of a Broadcasting Pioneer

ONE of the most colourful careers in the world of radio was brought to an abrupt close on Thursday, January 10th, when Charles Broadwell Popenoe, Treasurer of the National Broadcasting Company, U.S.A., died in the Miami Valley Hospital, Dayton, Ohio, after a brief siege of pleurisy and lobar pneumonia.

A pioneer in broadcasting, Mr. Popenoe was the manager of WJZ, the second broadcasting station in the United States, established at Newark, N.J., in 1921, by the Westinghouse Electric and Manufacturing Company. He piloted it through the early experimental stages, and in 1923 he was appointed manager of the Broadcast Division of the Radio Corporation of America, when that organisation took over WJZ, and moved its studios into Aeolian Hall, New York. When the National Broadcasting Company was formed in 1926 he became treasurer of the company.

According to an anecdote that his friends remember, Mr. Popenoe considered it a " raw deal " when he was appointed manager of the first broadcasting station. Broadcasting was considered something of a joke when, up in a little stucco house on the roof of the Westinghouse Company's building, he started his experimental station going. But with his transmitter installed he next found that he had nothing to broadcast; phonograph records were all that he could count upon. Artists did not know what he was talking about and were openly sceptical about the whole business, especially when they discovered that there was no financial compensation for their work.

At last Mr. Popenoe induced a few singers to take a chance. But his troubles had only begun. At any moment his set was apt to break down. And always on the floor below could be heard the whirr of the motor generator. The studio was just a corner of the ladies' rest room. The piano was frankly rented. The rest of the furniture was of mysterious origin. And the audience was altogether problematical. Yet WJZ was born and Mr. Popenoe was father of the second broadcasting station in the world.

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American Instrument Developments in 1928

A brief review of new apparatus, of interest to television experimenters, which has been produced in America during the past year

A TRANSMITTING valve operating on a wavelength of six metres and fifty times as powerful as preceding short-wave valves; added experiments with the cathode-ray tube, and a new recording spectrophotometer or colour analyser are among the research developments of the General Electric Company of U.S.A. during the past year.

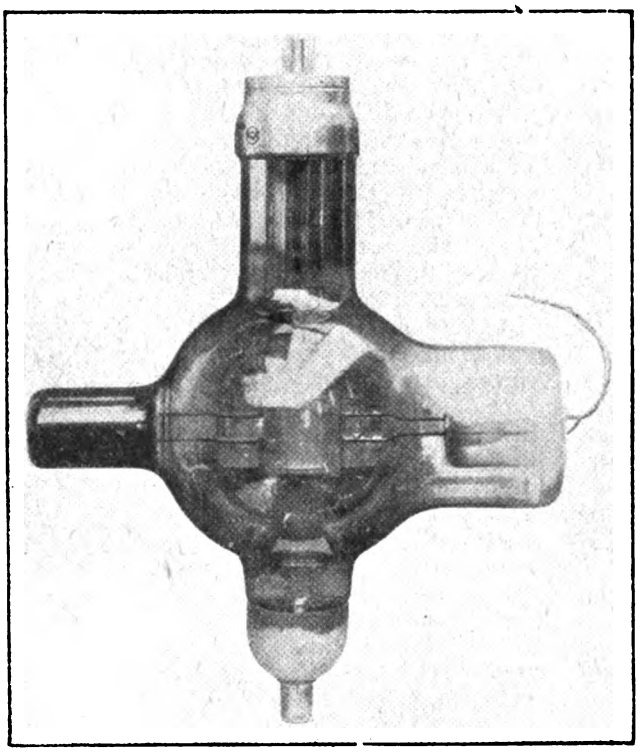
Valves.

A thermionic valve, five inches in diameter and about two feet long, was operated as a self-excited oscillator on a wavelength of six metres. It is capable of radiating from ten to fifteen kilowatts of high-frequency power — probably fifty times as much as any short-wave valve has heretofore been able to radiate. It is connected through a coupling system to a three-metre copper bar, which constitutes the tuned aerial circuit.

Several interesting physiological effects have already been noted in connexion with the new valve. Medical observations were made of several men placed near enough to the radiating antennæ to make possible measurements of changes in body temperature. It was found that the blood temperature rose to nearly 100° Fahrenheit in about 15 minutes, after which period the experiment was stopped. It was also found that a salt solution corresponding in strength to blood serum is heated most when placed very close to the high-frequency generator operating at about 50,000,000 cycles.

There was a decided increase in the use of screen-grid four-electrode valves in radio transmitters due to the fact that a large number of transmitters recently manufactured have been for short-wave operation and require certain wavelength control. Circuit stability and ease of adjustment have always been problems with short-wave transmitters in the past, and the use of the screen-grid valve prevents undesired coupling between the different parts of the circuits and thus greatly simplifies the design and operation of these transmitters.

A new form of rectifier valve for relatively high voltages and currents up to 20 amperes is of particular value for obtaining the high direct-current necessary for radio-transmitter operation.



[Photo by courtesy of G.E.C., U.S.A.
The new six metre transmitting valve.

These valves utilise the electron emission from a coated ribbon filament. A drop of mercury is included in each valve and the anode design is similar to that of the conventional mercury-arc rectifier. In comparison with the high-vacuum type of rectifier valve, this new mercury-vapour valve has the advantages of better regulation, better efficiency, and consequently higher output for a given size of valve.

Cathode Rays.

The cathode ray was utilised for the first time for the commercial inspection of the materials used in the production of meter jewels.

The cathode-ray oscillograph was provided with auxiliaries so that lightning itself caused the oscillograph to operate and record the magnitude, time, and frequency of the stroke. This opens up a new field in lightning investigation on power systems and makes possible the duplication of system effects in the testing of lightning arresters and other apparatus.

Colorimeter.

The exact duplication of any colour at any time and at any place has been made possible by a new colorimeter or spectro-photometer which eliminates human judgment and automatically, rapidly, and precisely measures the wavelengths of colours of any substance. Not only does it measure a colour accurately but it makes a record by which it is possible to reproduce it.

The instrument utilises a combination of an optical system and electrical devices whereby the specimen colour to be analysed is illuminated by a ribbon-filament incandescent lamp. Magnesium carbonate, the whitest substance known, is used as the standard of comparison in the laboratory instrument. The

(Continued on page 30.)

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The Theory and Action of the Simple Magnifier

Descartes' Work on the same—Telescopes

Part VIII

By Professor CHESHIRE, C.B.E., A.R.C.S., F.I.P.

IN a number of the preceding articles in this series, we have derived simply and fundamentally a few of the more important algebraic equations, a knowledge of which is necessary for the understanding, even in the most elementary way, of the optical action of such simple instruments as the microscope and telescope, or simpler still a pair of spectacles.

Given the position and size of an object, we are now able to find the corresponding position and size of its image as projected by typical optical systems, and we can go further and find the power and position of a single lens equivalent to a number of lenses in train. In the light of this knowledge we will consider more fully the action of such instruments as those referred to above.

Optical Aids to Vision.

Spectacles have already been dealt with. The optician in correcting the eye seeks to give it, when in the at-rest condition, a clear and well-defined picture of distant objects, and to supplement, if necessary, the accommodating power of the eye when satisfactory vision of near objects is required.

So-called normal vision for one age is not normal vision for another. A child of ten years of age can for the purpose of looking at near objects increase the converging power of its eye by as much as 14 diopters; in other words, it has a near point of 1/14 metres or 40/14, equal to 3 inches. With age the accommodating power falls off until at middle age—say, 45 years—it is not more than 4 diopters—i.e., the near point is now 40/4=10 inches away, and this is the case of normality that we will take as our standard. At 70 to 75 years of age all accommodating power has been lost.

Model Eye.

For many experiments in connection with vision, carried out on the optical bench, it is convenient to employ a model eye in the form of a tiny camera which may take the form of a short length of brass tube fitted at one end with a simple lens about one-third to half an inch in diameter, and with a focal length of two-thirds of an inch, which is the equivalent* focal length of the normal eye in air. The other end of the tube should be fitted with a small disc of ground-glass in the focal plane of the lens.

If such a model eye be directed towards a distant landscape there will be found upon the ground-glass screen images of distant objects identical in size with those projected upon the retina of the human eye when viewing the landscape in question. A more striking model can be made from a thin glass bulb (Fig. 1A) with a flat ground on one side to a depth sufficient to expose a hole abut one-third of an inch in diameter, over which the lens of two-third of an inch focus is cemented. The opposite side of the bulb is roughened to form a focussing screen. A model made up in this way will be employed in our experiments and shown in future diagrams marked "M.E.," the letters of course being a contraction for "model eye."

* The equivalent focal length of the normal human eye is more accurately 17·1 mm.

The Optical Action of a Simple Lens Magnifier.

When a page of small print is held sufficiently far away from the eye it cannot be read because the retinal image is too small. As the print is brought nearer, the retinal image increases in size until the print can be read. Brought nearer still, so long as the distance away is greater than 10 inches, the retinal image becomes still larger and still more easily read, because the eye calling upon its accommodating power maintains the retinal image in focus.

If the print be brought within

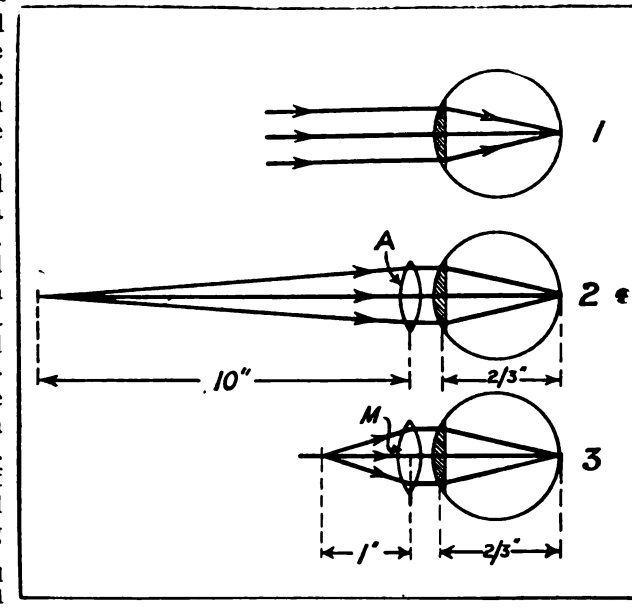

Fig. 1.
A model-eye for optical bench experiments.

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10 inches—the least distance of distinct vision—the eye cannot accommodate further, so that the rays from an object-point fall upon the retina *before* being brought to a focus; confusion of the image results, and the print cannot be read, not, be it noted, because the retinal image is not large enough, but because it is not in focus.

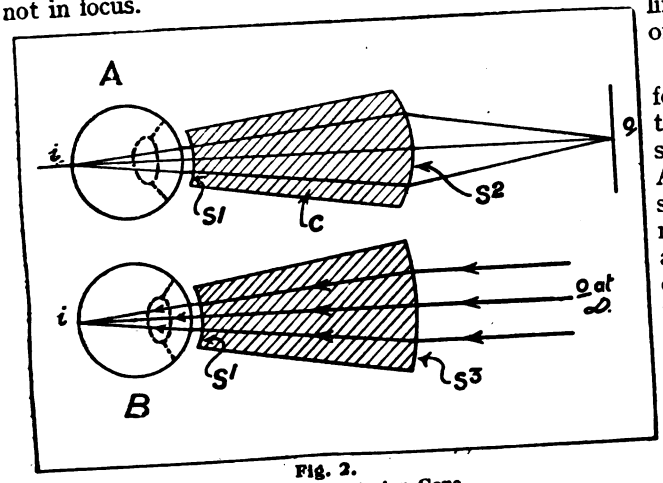

Fig. 2.
Optical Action of a Cartesian Cone.

Experiments with the Model Eye.

1. Mount the M.E. on the optical bench and observe that distant objects only, are in sharp focus on its screen or retina. Take a +4D lens (10 in. focus) and place it immediately in front of the lens of the M.E. This will now represent our normal eye fully accommodated.* Objects 10 inches away are in sharp focus, and, since the object is in the focal plane of the accommodation lens, the image must be in the focal plane of the lens representing the unaccommodated eye, so that we have in effect two lenses projecting an image of an object in the focal plane of one into the focal plane of the other.

Under these circumstances (see Fig. 3, p. 41, of the January issue of TELEVISION) the size of the retinal image is equal to that of the object multiplied by the focal length of the eye—two-thirds of an inch—and divided by that of the accommodation lens—10 inches—the retinal image is then 1/15 of the size of the object, so that it is minified.

If we now take the accommodation lens *A* away and replace it by a short focus lens *M*, we have, suitable for our optical bench experiments, a model eye unaccommodated, but fitted with a magnifier. If the lens *M* has a focal length of one inch, say, then the retinal image will be two-thirds of the size of the object, i.e., *ten times greater than when the object is seen at a distance of* 10 *inches with the unaided eye.* For this reason a one-inch magnifier is said to give a linear magnification of ten times.

In practice, therefore, it is not necessary to take account of the sizes of retinal images. An object is said to be seen under *unit* magnification when it is at the conventional distance of 10 inches from the eye. When, as in the use of a magnifying lens, this distance is lessened to the focal length (f) of that lens the magnification (M) is obtained by dividing 10 inches (λ) by the focal length (f)

$$M = \frac{\lambda}{f} \quad \ldots \quad (1)$$

A two-inch focus lens, when used as a magnifier, gives a magnification of five, whilst a powerful pocket lens of one-third of an inch focus gives one of $10/\frac{1}{3} = 30$ times.

The simple magnifier, or its compound equivalent, derives its importance from the fact that it is used, not only for the direct observation of accessible objects, but also for the observation of the aerial images of inaccessible objects, as in the telescope, for example. Here an aerial image of the moon, say, is projected in air by a comparatively long-focus lens, the object-glass—and this image is observed by a short-focus magnifying lens or lenses.

We will now digress to consider for a short time a fascinating chapter in the history of our subject.

The Eye of a Giant-Cartesian Telescope.

The famous philosopher, Descartes, published his great work entitled "*Discours de la Méthode*" in the year 1637, some thirty years only after the invention of the telescope. One of the most interesting and valuable of the parts of this book bears the sub-title "*La Dioptrique.*" In this, amongst other optical matters, Descartes deals at considerable length with the eye as an optical instrument. He knew that the size of the retinal image, and, therefore, the apparent size of an object depended upon the ratio of the diameter of the eye, to the distance away of the object itself—the bigger the eye the bigger the image, and the bigger the apparent size under which an object was seen.

Starting from this fact he proceeded to invent a simple type of magnifying instrument, which is still referred to as a Cartesian telescope, and which depends for its action upon the changing of a normal eye, for the time of an observation, into the eye of a giant. Descartes then, with the object of increasing that diameter of the eye effective for optical purposes, took a hollow truncated cone of sheet metal, the outer and bigger end of which was glazed with a disc of glass shaped like a common watch-glass, with its bulge outwards.

In use the cone was completely filled with water and then the smaller end was applied to the eye in the manner of an eye-cup. In this way, as Descartes pointed out, the refraction

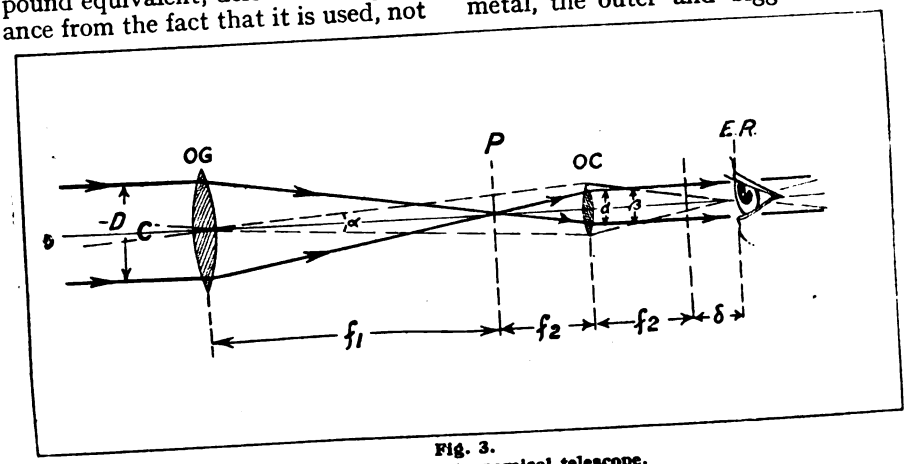

Fig. 3.
A diagram of an astronomical telescope.

* It is convenient to represent the accommodation by a separate lens in optical bench experiments. In the eye of course accommodation is effected by an increase in the curvature and therefore in the power of the crystalline lens.

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which occurs when a ray passes from air into the eye is done away with and transferred to the curved window at the outer end of the tube. The diameter of the eye, effective for imaging purposes, was thus increased by the length of the cone of water. By a suitable choice of the curvature of the outer end of the cone Descartes showed that the water could be replaced by glass. This is always done in the modern form of the instrument. Similar lenses known as Steinheil *loupes* have been made for the correction of high degrees of myopia.

Fig. 2A shows a diagrammatic copy, so far as is necessary for our purpose, of a figure which occurs in "*La Dioptrique.*" The smaller end of the glass cone S^1, is ground to the curvature of the cornea, but it is shown slightly separated therefrom to permit of simplification of the description of the optical action.

The curvature of the front surface is so calculated that light rays from an object point *o* are so refracted by it that, upon reaching the surface S^1, they are refracted out into air as a parallel bundle, in which condition they enter the eye and are brought to a focus in the image point *i* on the retina. In the case of a water cone, the surface S^1 is in contact with the cornea so that rays pass across the junction without refraction.

Fig. 2B shows a Cartesian cone with its front surface of such a curvature that parallel rays from a distant point are refracted at the ends of the cone in such a way that they emerge parallel to one another. In this case, therefore, the cone is a one-piece Galilean telescope or opera-glass.

Magnifying Power of a Telescope.

The magnifying power of a telescope can be derived quite easily from first principles. Suppose that we have a photographic camera with a lens of 12 inches focus throwing an image of a distant landscape on to the ground-glass screen. If we could look into the lens without obstructing the light rays, we should see the image of the landscape of the same apparent size as the landscape itself when viewed in free vision from the same spot.

Getting behind the camera and looking at it from a distance of 6 inches (we are supposing that the accommodation power of the observer is adequate) the image would be seen of twice its apparent size as seen through the objective or in free vision. Generally, the magnification would be obtained by dividing the focal-length of the photo lens by the distance at which the observer's eye is placed. If now the latter takes a 1-inch focus magnifier to look at the picture the rule still holds, and the magnification will be $12/1=12$ times.

By taking the screen away the aerial image will be seen and, without altering the magnification, we have converted our camera into a telescope. If f_1 be the focal length of a telescope object-glass and f_2 that of its eyepiece then the magnifying power is got from—

$$M=\frac{f_1}{f_2} \quad . \quad . \quad . \quad (2)$$

Example: The focal length of the O.G. of a prismatic binocular is 120 mm. and that of its ocular 20 mm. Its magnifying power is $120/20=6$ times.

In Fig. 3 we have a diagram of an astronomical telescope which gives, of course, an inverted image of a distant object. A pair of incident rays are drawn through the upper and lower edges of the O.G. which come to a focus in the plane *P*, which is also the focal plane of the ocular. After passing through the latter the two rays emerge parallel to one another and enter the eye as shown. Another pair of rays, shown in dotted lines, pass through the centre of the O.G. on to the ocular, by which they are brought to a focus in the so-called eye-ring, or Ramsden circle E.R.

From this diagram we can deduce important facts. First as to magnification. It is obvious that a small object seen under the angle α, in free-vision will be seen under the angle β, through the telescope. These angles being small,

$$\frac{\beta}{\alpha}=\frac{f_1+f_2}{f_2+\delta}$$

but from equation 4, on page 37 of the November issue of TELEVISION, $\delta f_1=f_2^2$, so that the magnifying (M) power of the telescope is—

$$M=\frac{\beta}{\alpha}=\frac{f_1}{f_2} \quad . \quad . \quad .$$

agreeing with the result obtained from first principles.

Again the diameter D of the incident beam is reduced to a diameter d in the emergent beam. But $D/d=f_1/f_2=M$. Thus, finally, the magnifying power of a telescope is obtained by dividing the diameter of an incident beam by the diameter of the corresponding emergent beam—an important fact made much use of by the opticians.

American Instrument, etc.

(*Concluded from page 27.*)

light from the incandescent lamp falls perpendicularly on both the specimen and the magnesium carbonate standard and, after reflection from them, enters the slit of an ordinary spectrograph system.

Immediately in front of the slit is a rotating glass disc having alternate silvered and transparent segments. The disc is so located that light from the standard enters the slip when a transparent segment is in the beam, and light from the specimen when a silvered segment is in the beam. The spectrograph system disperses the light and a second slit selects the proper wavelength band. Light passing through the second slit falls on a photo-electric cell which receives monochromatic, or single wavelength light, of pulsating intensity when the standard and specimen reflect different amounts of light in the spectral region.

This pulsating light intensity is changed to a pulsating current by the photo-electric cell, is amplified, and is then employed to run a small motor. This motor actuates a shutter in the beam between the light source and the standard, and automatically finds a position where the pulsations of the light cease. This position is independent of the characteristics of the photo-electric cell. A pen, attached to the mechanism controlling the shutter, records the reflecting power of the specimen on the rotating drum. A second motor rotates the drum and at the same time drives the slit across the spectrum, thus giving a complete colour analysis in less than a minute.

WGY, the Schenectady station of the General Electric Company, and the first station anywhere to offer television on a regular schedule, discontinued television transmissions on January 1st. However, experimenters interested in receiving television signals will continue to find them on WGY's two short-wave transmitters, W2XAF and W2XAD, operating on 31.48 metres and 19.56 metres, respectively. The present schedule calls for afternoon transmissions, Tuesday, Wednesday, and Friday, 1.30 to 2, and Sunday evening, 11.15 to 11.45, by W2XAD, and Tuesday evening, 11.30 to midnight, by W2XAF.

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The Television Society

Report of the February Meeting

ONE of the best attended meetings of the Television Society was held at the Engineers' Club, Coventry Street, London, on Tuesday, February 5th, to hear Mr. Ronald R. Poole, B.Sc., lecture on "Methods of Light Modulation in Television Receivers."

In the absence of Dr. Clarence Tierney, the Chairman, who was laid up with influenza, the chair was taken by Mr. W. G. W. MITCHELL, B.Sc., Joint Hon. Secretary, who, introducing the lecturer, referred to the number of members present and mentioned that extra chairs had had to be sent for.

He had received a letter, he said, from Dr. Tierney saying how sorry he was not to be with them. He was sure they would join with him in sending Dr. Tierney their sympathy coupled with a sincere hope that he would soon be quite fit again.

The meeting was a notable one because Mr. Poole was originally assistant to Dr. Fleming and was now assistant to Professor Clinton, who had only recently taken over the Chair of Electrical Engineering, which at one time was held by their President, Professor Fleming, at University College. They would be interested to hear that Prof. Fleming, who had been abroad for health reasons, had recently returned looking very cheerful and fit, in spite of his advanced age.

It had originally been decided that the meeting should be an informal one and an exhibition of work, but when Mr. Poole had been secured to lecture the Committee had postponed the informal meeting to next month, feeling that a lecture on such a subject would be of general interest.

Personally, he was glad, for the extra month would enable them to put on a really good show. The Council felt, too, that the informal meeting would be a real opportunity for members to meet and get to know one another a little better than they had had a chance of doing at the rather formal lecture gatherings.

The subject of light modulation was almost the essence of television. There were few better qualified to speak on the matter than Mr. Poole, who had been experimenting for some time in that direction, and, if he might say so, had unique opportunities at his disposal for experimental work of that kind.

It gave him very much pleasure to call on him to give his lecture.

Mr. POOLE said the Chairman had referred to the subject of light modulation as being the essence of television, and he thought in many respects that was so. One might contend that the initial proceeding of converting the light into electric energy—the photo-electric cell one might say was more important because it naturally came first—but methods of doing that were known for many years before any satisfactory way was found of reconverting the electric impulses into light.

The discovery of selenium and its strange property of being sensitive to light was made about the middle of last century, and it led to a considerable revival of the long investigated and long pondered over subject of television.

One of the earliest means by which this was carried out in any practical form was to have a vast array of selenium cells arranged on a screen upon which an image of the subject was projected by means of a large lens. Each cell then responded to a small portion of the subject and the electric current produced by the amount of light falling on it was transmitted along a wire to a kind of galvanometer acting on a small shutter allowing light to pass

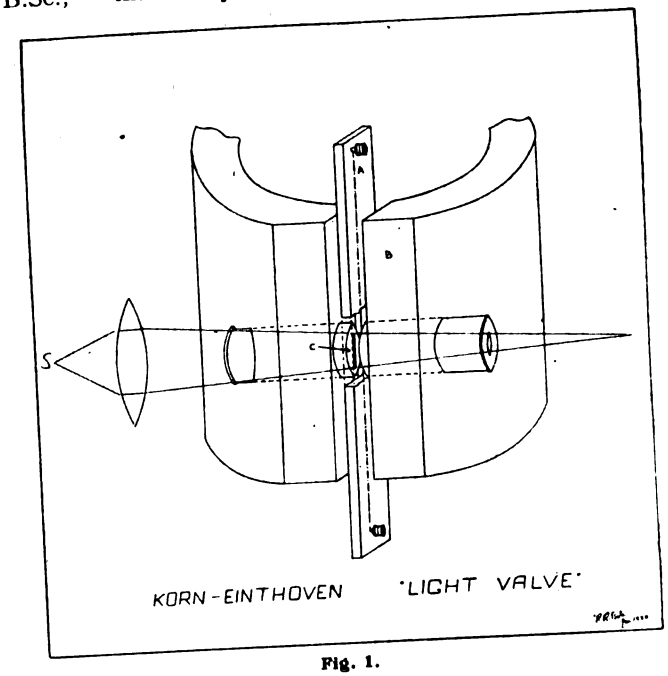

Fig. 1.

Korn Einthoven Light Valve.

This consists of a fine metal strip A, about ·05 mm by ·003 mm., stretched between the poles of a powerful electromagnet B, and connected to the receiver. Currents cause it to deflect, uncovering more or less of the strongly illuminated slit in the diaphragm C, and allowing light to pass in proportion to the received signal.

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from a lamp. The method was, of course, extremely cumbersome, but it was used recently by Rignoux and Fournier to demonstrate a principle of television—a *principle* rather than a method.

They arranged sixty-four cells in eight rows of eight each, and each was connected by wire to a small galvanometer whose needle operated a shutter. It was evident also that that system could only have a very limited application. For one thing, a separate channel had to be provided for each cell, which, of course, made it impossible to extend it to anything like the extent found in nature, where the light-sensitive cells in the eye, corresponding to the selenium cells, are connected with the brain by an enormous number of channels.

It was found then that more satisfactory results could be obtained, although the method was not available, if the image could be divided up into a number of small sections, each section transmitted one after the other with such rapidity that the whole image could be transmitted at least sixteen times a second.

This at once ruled out the prospect of using any kind of mechanical shutter, already referred to, on account of the great speed with which it would have to operate. Its inertia would preclude all possibility of its moving at the required speed.

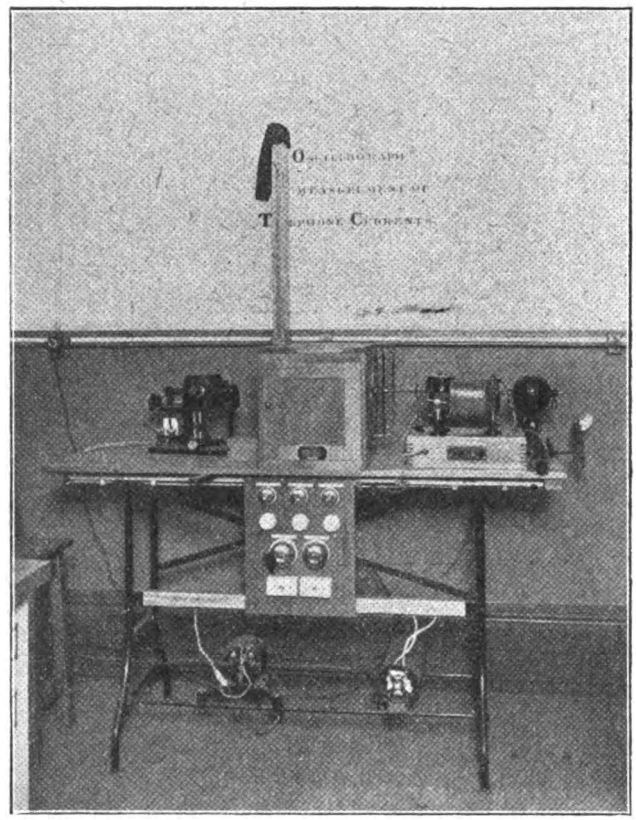
The Korn Light Valve.

About 1908 Professor Korn invented what he termed a "Light valve," employing the principles of the Einthoven galvanometer (see Fig. 1). It consisted of a fine wire suspended in a magnetic field produced by an electro-magnet of considerable depth. Through one hole of the magnet was a tunnel and in a corresponding tunnel in the other limb of the magnet was placed a kind of telescope. In it was a disc with a narrow slit cutting down the light passed. The slit was normally covered by the wire between the holes of the magnet. In this case the wire took the form of a narrow strip of material about one mil thick and four mils wide. The strip was so placed that normally all light was cut off from the slit.

On receiving a small current through the wire it was reacted on and deflected sideways, and of course uncovered more or less of the slit, and allowed light to pass through. The light was collected by a lens and brought to a focus, from which it could be reconverted into an image in the usual way by some kind of oscillating mirror or by a rotating wheel, as in the Baird system.

At the time it was used only for telephotographic purposes and found very satisfactory because the drum carrying the film was rotated slowly with a spiral motion and the concentrated point of light, of course, printed on a sensitive film permitting more or less light to pass according to the signal received. This also had been tried more recently for television purposes, but it had certain disadvantages, one of them being that the amount of light obtainable through the slit was very small.

It must also be remembered that in any form of television the average intensity of illumination on the screen is equal to the amount which can be got by distributing the point of light which traverses the screen over the whole screen. This was one of the objections to building up an image by the light-spot method. In telephotography the objection did not hold because the reproducing mechanism was worked very much more slowly, and of course the slower it ran the greater the effect of the light on the sensitive film. The average time taken to print off a picture measuring about 6 inches square with the method was about 15 to 20 minutes. As all that in television had to be done within one-sixteenth of a second such a method was ruled out.



A Duddell oscillograph, as installed in the new department, now known as the Communications Department, University College, London.

Szczepanik and Mihaly.

Light valves seemed for some time to be the only possible way to get at the problem of reconverting the electricity into light. Various methods were tried. In 1908 Szczepanik used the system in a modified form and later Mihaly in Austria also made use of it (see Fig. 2).

In his system the image of a slit in a screen situated in a beam of light was directed on to a small mirror in a Duddell oscillograph. Two fine wires situated in an intense electric field had a small mirror cemented to their centres. Current was led up one wire and down the other, and their combined movement caused the mirror to oscillate.

If the image of the slit was projected on to a triangular slit any movement of the mirror caused more or less light to pass through the triangle. The lecturer showed a rough demonstration model of this apparatus, the light point reflected from the mirror, which was mounted on strings, being thrown through the triangular slit on to a ground glass screen.

Continuing, Mr. Poole pointed out that if in place of the ground glass screen there was a lens to further concentrate the beam of light on to a mirror or revolving disc or other reconstructing mechanism, it would be possible to reproduce the original picture.

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This scheme suffered from the same defect as Korn's apparatus, i.e., if the mirror was to be small enough to vibrate fast enough it was going to be too small to reflect much light.

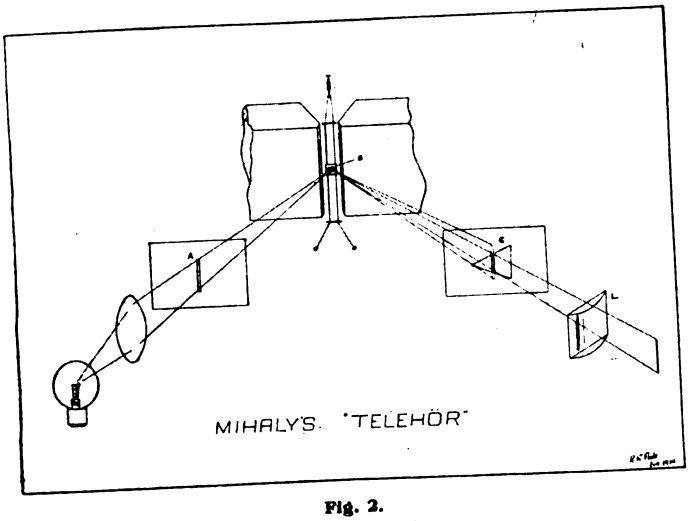

Fig. 2.

Mihaly's Telehör.

The image of a strongly illuminated slit A is focussed on the vibrator mirror B of an oscillograph of the Duddell type. The reflected beam traverses a triangular opening in a screen C and is conveyed to a line of varying length at D by a cylindrical lens L. The amount of light passing the screen will be proportional to the deflection of the beam and hence to the current.

The system was, however, useful in telephotographic work, where speed of operation was not of first importance.

This objection, too, was fundamental in all mechanical reproducers of that kind, for the mirror could not be made to go fast enough if it was of any useful size.

The defect led to much investigation on other lines, but at that time the thermionic valve had not been invented—it did not make its appearance until about ten years after these inventions were tried, being invented about 1912, and it was not until about 1915 that it had developed sufficiently to be of use in television work.

Cathode Ray Oscillograph.

Other lines of research led to the cathode ray oscillograph, which had attained a certain degree of perfection.

The illustration thrown on the screen (see Fig. 3) was of a hot cathode type of tube. At one end was a screen of glass covered with some active material such as calcium tungstate or platinum sulphocyanide, each of which emitted a glow when impinged upon by the rapidly-moving stream of electrons.

The filament of the tube was platinum, usually coated with lime, which emitted a generous stream of electrons. The tubular plate had about 500 volts applied to it and imparted to the stream of electrons a high velocity, so much so that they were carried past it and impinged on a small glass diaphragm placed in the middle of the tube. In the centre of the diaphragm was a small hole roughly of the same area as the stream of electrons. Those which passed through travelled along the core of a solenoid which was used to concentrate the beam of electrons and imparted a rotary motion to it. Normally they tended to spread by reason of their mutual repulsion. The solenoid, by concentrating the beam, gave a cleaner, sharper spot of light on the screen.

A form of modulation of the beam could be got by electrical means. The simplest way to do it was by a magnet so arranged as to give a field across the tube. This diverted it so that only a portion passed through the hole in the diaphragm.

The tube possessed certain great advantages which were first pointed out by Campbell-Swinton about 1908. If one could give the beam two motions at right angles to each other a suitable way of reconstructing a television image would be available.

Small Field Required.

The simplest way to do this was to pass the stream between a parallel pair of aluminium plates. A potential applied to them drew the beam towards the positive plate while the negative plate repelled it. Two pairs of plates placed at right angles to one another provided the necessary means to give the beam a dual motion. The field required to divert the stream was very small, in fact so small that it could almost be provided from the first stage of amplification of a wireless receiving set. That was a further advantage because one of the great disadvantages in television was the enormous amplification of the signal which was necessary.

However, the whole arrangement was not very satisfactory. For one thing, the tubes were extremely expensive and had a short life. One tube on the market had a life of about 100 hours running and cost £30.

A cathode-ray tube was demonstrated by Mr. Poole, who explained

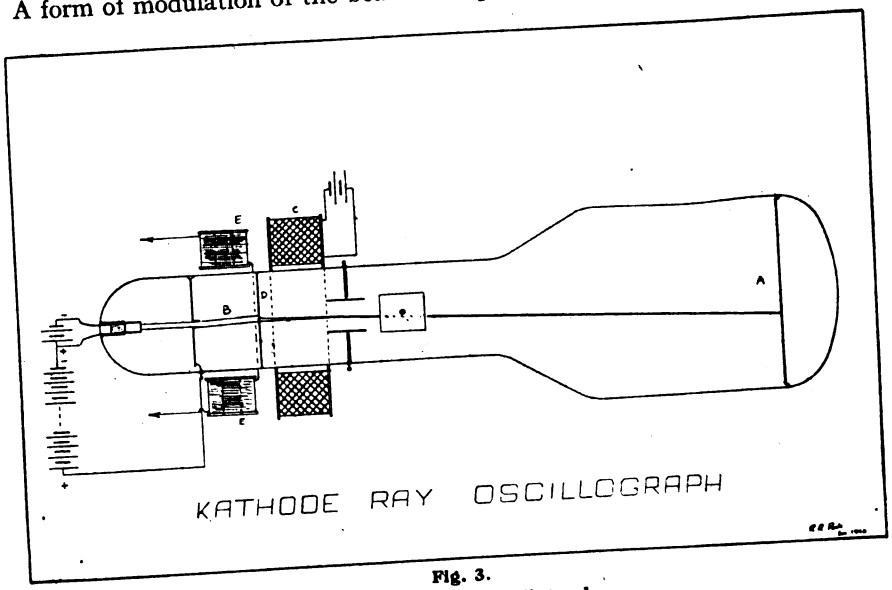

Fig. 3.

The Kathode Ray Oscillograph.

In this the electron beam B is deflected by a field from small electromagnets E connected to the receiver. The beam has to pass through a hole in the glass diaphragm D and the amount passing varies inversely with the deflection and hence with the received signal. The beam is focussed on the fluorescent screen A by means of a solenoid, C, and may be made to traverse this screen by means of deflector plates or electromagnets, so as to reconstruct the picture.

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that it was of a type known as the "cold cathode." It had a nickel reflector from which electrons were torn off by very high voltages, the present tube requiring about 2,000 volts for that purpose.

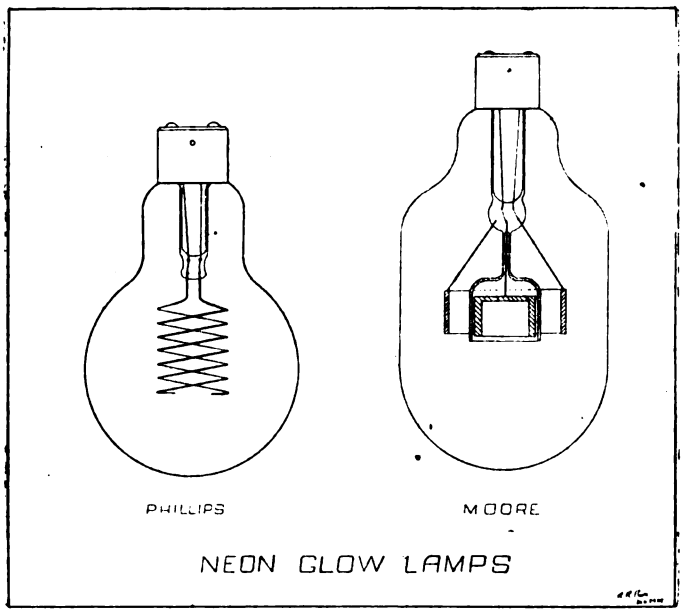


Fig. 4.
Moore's lamp and Phillips's 100-volt neon lamp.

The cold cathode tubes had been known for many years and were very useful in work where the ordinary Duddell oscillograph was unsuitable. One of their great advantages was that the electron beam had no inertia and could be quite easily deflected by an electrostatic field or a magnetic field.

The deflection of the electron stream was demonstrated by the use of an ordinary permanent bar magnet which, even when held a considerable distance from the tube, deflected the beam.

Neon Tubes.

After the oscillograph method came more modern developments which involved the use of neon or other gas-discharge tubes. These tubes owed their development to Mr. Baird, who had done more towards their improvement than most people.

One of the earliest types of neon lamp used was a long tube bent backwards and forwards on itself and supplied about every inch along its length with separate pairs of electrodes. These corresponded to the large number of shutters which were employed in earlier attempts at television, but, unlike them, only one channel of communication was required, each pair of electrodes being fed separately through a commutator running synchronously with the scanning mechanism, so that the various parts of the neon tube were switched in one after another, the whole traversal of the screen being made about sixteen times a second.

A lantern slide of such a neon tube was shown, the lecturer explaining that the tube made up a screen about four feet square. One of the electrodes was in the form of a continuous spiral throughout the length of the tube, while the other took the form of small bands arranged at intervals of an inch along the tube, or small electrodes sealed in the glass wall about an inch apart. A slide showing the detail construction of the tube was shown, together with an illustration of the commutator arrangement, and Mr. Poole then explained that this was the only way to secure a large television image because the light obtainable from a single neon tube was quite small and not sufficient to illuminate a large screen. They would notice that on many of the Baird receivers the screen was quite small, but was viewed through a lens to give a larger picture.

With a screen measuring 4 feet by 4 feet about 500 watts was the least that could be used if one was to have any definition.

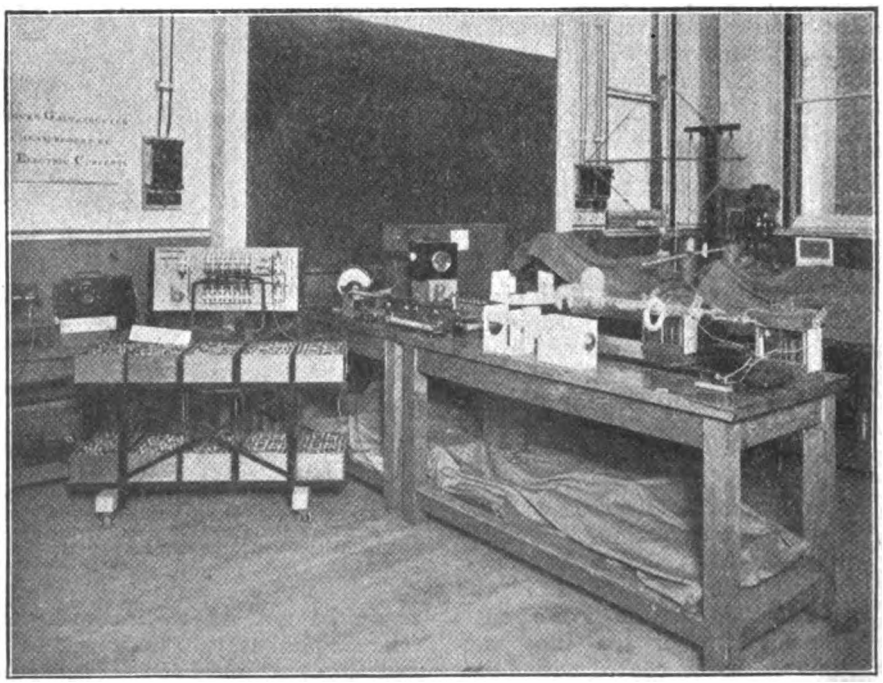
A single neon tube used about three or four watts, which was, of course, quite insufficient for a large screen.

Limit of Illumination.

With the large tube illustrated the illumination could be pushed up to a considerable extent, but it did not seem likely that such a method would be very generally used on account of its complication, although it had its uses in large-scale work.

A somewhat similar device was suggested many years before Mr. Baird started, only using electric light globes instead of the continuous neon, very much on the lines of the present-day electric signs. The time-lag of the electric light globe rendered it quite impracticable for any purpose of that nature.

On the other hand, gas-discharge lamps of the neon type had an absolutely negligible time factor, a



A view of the apparatus used by Mr. Poole for demonstration purposes (on table in foreground).

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characteristic which made them very suitable for television work.

Mr. Poole then illustrated the

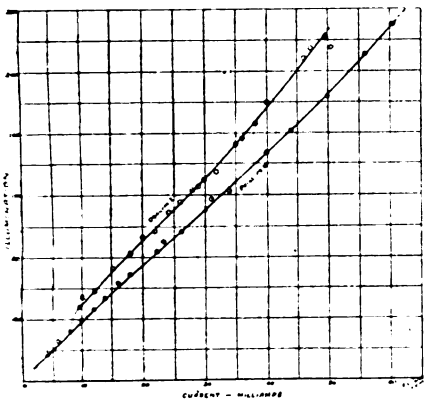

Fig. 5.

Graph of illumination against current obtained with Lummer Brodhun photometer using a 220-volt Osglim lamp as standard. The illumination units are arbitrary.

common type of neon lamp as sold for domestic purposes (see Fig. 4), and said it was rather suitable for amateur television work. For that reason he had done a good deal of experimental work with it to find its characteristics.

If used in the output circuit of the last stage of an amplifier the current passing through the lamp was going to be proportional in some way or other to the incoming signal, and the amount of illumination was going to be proportional to that signal. If they could reconstruct the image from that varying point of light then they had solved the problem of television apart from the difficulty of colour.

Of course, the first thing to find out was how much the illumination depended on the varying quantities associated with the lamp, and whether the illumination was proportional to the current or the power.

Neon Tubes Practical.

Mr. Baird apparently had found them quite satisfactory because they were used now almost exclusively in the only practical televisors available.

Discharge tubes of that kind could be filled with gases other than neon, which gave a characteristic red glow.

Lamps had been made with hydrogen, helium, argon, and other gases of that character. Most of them had a bluish or other characteristic colour, and a variety of colours could be obtained by a mixture of various gases. Sodium vapour gave a yellow, and a mixture of sodium and mercury gave a greenish yellow, which, in conjunction with neon and argon, gave a fairly good reproduction of white light. Alternately three separate channels could be used. Mr. Baird had already produced an instrument working on the three-colour system, which reproduced the image in its natural colours.

That was a matter very far in advance of the foreign inventors and showed signs of being a very important development.

The Moore Tube.

Another lamp developed by Moore in America (Fig. 4) worked on the principle of the cathode discharge, and consisted of a cathode in the centre, having a hollow in it. It was surrounded by a glass bell which screened the outside of the cathode, leaving only the hollow exposed. Outside this was placed a ring-shaped electrode. In this type of

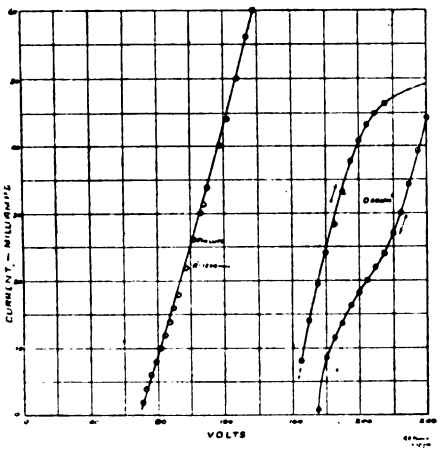

Fig. 6.

Graph of current against voltage in Osglim and Phillips's lamps. The values of current in the case of the Osglim were those reached after several minutes at each voltage.

lamp the glow was concentrated in the hollow in the middle and gave a very intense point source of illumination. This was of advantage, for the light was much more easily dealt with optically. A lamp having two spirals of wire around which the glow appeared was not the best type for television work because of the diffuse nature of the light source, but otherwise it was satisfactory, particularly because the amount of light obtained was very large for the power available.

Mr. Poole then showed two graphs (Figs. 5 and 6) which, he explained, showed illumination plotted against current passed in milliamperes.

The voltage was applied from ordinary batteries and regulated by a potentiometer, the current being measured directly. The illumination was measured by an Osglim lamp placed at a standard distance from the photometer.

A disadvantage of neon was that the light slowly altered with the current passed through and at the higher voltages tended to become somewhat pinky. It would be seen that the lines on the graph were nearly straight, showing that the illumination varied almost directly with the current.

A number of lamps were tried and nearly all gave the same light for current curve, although the results varied considerably. Possibly this was due to the fact that the production of reasonably fine neon was an expensive process. Consequently, commercial lamps were filled with very impure gas and different batches of lamps showed slightly different characteristics.

Neon Characteristics.

Any given lamp, however, showed very little variation in the results it gave over a fair period.

The next graph shown was of current plotted against voltage and was an almost straight line. It showed the A.C. impedance of a neon to be about 1,200 ohms, a figure which remained reasonably constant in extreme conditions of temperature and length of run.

When a sine wave voltage was applied to the neon the consequent oscillograph record showed that up to a voltage of about 70 no current flowed in the lamp at all (Fig. 7). It then suddenly started and rose almost perpendicularly on an increase of voltage until nearly the peak of the curve was reached, when it began to

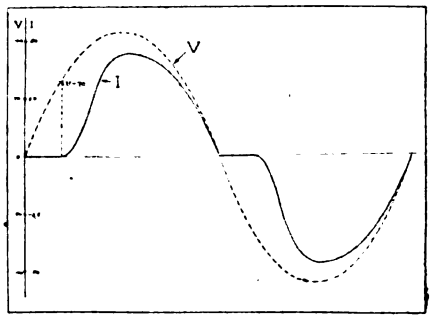

Fig. 7.

Copy of oscillogram of current in Phillips's lamp with sineform voltage.

bend over. On the falling side of the curve the current did not stop flowing until a lower voltage was reached. If a neon was put in the

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plate circuit of a valve, say of the L.S.5 type, this effect was accentuated and the lamp often remained alight when extreme values of grid bias were applied.

Such a characteristic was not desirable if the neon was required to follow faithfully in light the voltages applied to it, for it meant that if one was using it to reconstruct a television picture one would have too much light during the transmission of the shadows in the original.

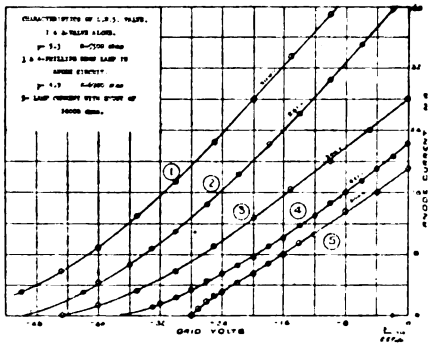

Fig. 8.
Characteristics of valve with lamp in anode circuit.

Various experiments were tried and it was found that the inclusion of a resistance across the neon had the effect of bringing the striking and extinguishing voltages much nearer together. With a voltage of 200 applied to the anode of an L.S.5 the resistance required was about 10,000 ohms.

A neon lamp used in that way could be made to give very good results indeed, as those of them who had seen Mr. Baird's demonstration last December would agree. Personally, he thought the results obtained at that demonstration were astonishing.

There was one other method of light modulation, but very little work had been done with it.

Another Method.

It was discovered about 1875, although at that time its application to television purposes was not suspected. A couple of nicol prisms were used and the beam of polarised light passing between them had to traverse a tank filled with carbon disulphide.

The first beam situated in a beam of light passed a beam in which the light vibrations were all in one direction. By rotating the second prism this beam was alternately blotted out or allowed to pass, depending on the relative positions of the prisms. If, however, when the prisms were in the extinction position a powerful magnetic field was applied in the direction of the beam of light it had the same effect as rotating, more or less, one of the prisms. In air this field had to be very intense, but in carbon disulphide quite a weak field had the same effect.

A model of this apparatus was shown by Mr. Poole, who explained that as he could find no suitable tank to contain the carbon disulphide, and as that chemical had a most unpleasant smell he had decided to omit that part of the apparatus.

Instead he rotated one of the prisms by hand and showed how the light passed, varied from absolute darkness to its full value over 90 degrees of rotation.

Little work had been done on that system of modulation, he said, and it offered a very interesting field for investigation.

Mr. MITCHELL thanked the lecturer for his critical and informative lecture on light modulation methods.

Measurement Difficulties.

He knew something of the difficulties of getting measurements on neon tubes. A short time ago he had reproduced some graphs in TELEVISION, and since then had been inundated with letters from people who could not get their tubes to strike at the voltages that his had struck at.

It was that kind of work that the Society should take up and, not having the facilities at the moment, Mr. Poole was the kind of member they wanted, for he came along and said " Bring these things to me and I will see what I can do in the way of measurements."

He most sincerely thanked Mr. Poole for his lecture and thought that the fact that he had kept them all interested for an hour and a half was a matter of which he should be proud.

He hoped they would all get enthusiastic about the exhibition next month. He had been very busy on it lately and most satisfactory replies had been received to a number of enquiries and many members had promised to bring apparatus along.

As Mr. Mitchell had to leave to catch a train he handed the duties of Chairman over to Mr. WM. G. KEAY, treasurer of the Society, who also congratulated Mr. Poole on his lecture and said it would be an inspiration to those of them who had not taken up that branch of television He had touched on such a number of points that were of particular interest that he was sure they were anxious to ask questions, which he was equally sure Mr. Poole would do his best to answer.

Many Questions.

Replying to many questions, Mr. Poole said the failure of the cathode ray tube after 100 hours or so of running was due entirely to the loss of emission of the filament. Tubes had been built which were demountable and in which new filaments could be fitted, but it meant that when that was done the tube had to be re-exhausted.

The current requirements of the hot cathode type of tube were of the order of a few milliamperes. In the cold cathode type, where the voltages were very much higher, the current requirements were much lower. The one he had demonstrated required about two or three milliamperes, and it was possible to work the cold cathode off a Wimshurst machine.

The Moore neon tube was employed in exactly the same way in a receiving set as the ordinary neon tube, and the point of light could be focussed or projected on an oscillating mirror.

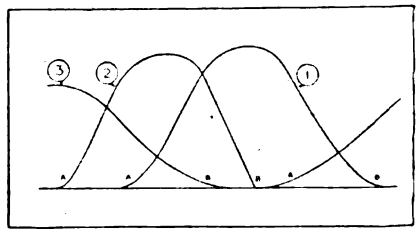

Fig. 9.
Oscillograms of lamp current with and without shunts with A.C. applied to the grid of the valve.
(1) Current in lamp without shunt. Applied grid volts 20 R.M.S. and −30 bias.
(2) Current with shunt. Applied grid volts 20 R.M.S. −30 bias.
(3) Current (to larger scale) without shunt. Applied volts reduced to 4 R.M.S. −30 bias.

Overlap.

The reason for the neon striking at one voltage and going out at a lower one was somewhat obscure and had never been properly cleared up. It was common to all glow-discharge tubes and was due to the fact that the gas remained incandescent for a fraction of a second after the current ceased. If it was watched when caused to glow by a very rapid spark it would be found that the glow persisted for a fraction of a second

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after the discharge had passed. That was sufficient to maintain the temperature of the gas and keep its impedance low enough to allow the current to pass.

With regard to the cathode-ray tube there was no secondary emission from the rays striking the screen. If there were the rays would be moving quite slowly, and it must be remembered that the screen itself was not charged at all and was non-conducting —therefore there was no particular reason why the screen should glow.

As to getting the cathode ray outside the tube they must not forget that glass was opaque to it, and when the rays struck the diaphragm inside the tube they were lost to the eye. At the same time he believed tubes had been manufactured with a screen which was transparent to the rays and they had been projected beyond the tube.

This concluded the questions, and then Mr. MITCHELL (who had not caught his train) announced that he had been stopped by a member, and as a result of the talk they had had, he thought he could promise them that there would be a cathode-ray tube on view at their exhibition next month.

Cathode Ray Tube to be Exhibited.

This member had done some work with the tube, and it was claimed that not only could results be obtained with it, but colour screens could be interposed and colour work done. There was a need for a good deal of work to be done on the actual screens themselves.

The cathode ray was a most fascinating way of getting light modulation, for there was no inertia to consider when dealing with a beam of electrons.

With regard to their exhibition, now postponed to next month, many members had promised to bring apparatus along "if it worked." But that was not what was wanted. They wanted them to bring apparatus along even if it did not work. Other members might perhaps be able to suggest methods of making it work, and in any case they could discuss it and perhaps find out why it failed to operate.

Also the secretaries were anxious to know what space members required and whether they wanted a current supply of 5,000 volts or 200, which was the standard there.

Historic Exhibits.

They would also be interested to know that Mr. Lloyd Atkinson, a past-President of the Institute of Electrical Engineers, had promised to bring his earlier historic apparatus, which dated back 200 years, along to the Exhibition.

Mr. POOLE, briefly replying to the vote of thanks accorded to him for his lecture, said he would be glad at any time to undertake investigation and measurement work for members in connection with any difficulties they might meet.

Society Notes.

When the history of the Television Society comes to be written, as no doubt one day it will (for surely most societies allow themselves a little licence in such matters on the occasion, at least, of the centenary of their coming into existence!), we hope to find the February meeting marked down with honourable mention. For, in the first place, the lecturer was right; young, and full of enthusiasm for his subject, speaking carefully (and we would add in parenthesis, *audibly*), critically weighing and analysing each of the methods of re-forming the image at the receiving end. This lecture was just the kind we like to have. So crammed full was it of sound reasoning and impartial judgment on the various methods which the lecturer discussed, that it was in itself sufficient to start a veritable volley of questions. And this is just how the lecture was rounded off.

The audience was right, too; numerically in excess of any previous meeting since the opening meeting of the 1928 session, when Mr. Baird occupied the platform, and a tribute to the excellent "staff work" which we happen to know has been going on at Headquarters recently.

But when the proceedings opened the genial presence of our chairman was missed. Dr. Tierney had a few days previously been lecturing in Glasgow and had managed to contract a nasty chill, from which we are happy to add he has now almost recovered, but which was sufficiently severe to keep him away from the meeting on February 5th. The chair was occupied by one of our secretaries, whose name now appears at the foot of those lecture notices which summon us each month to the Engineers' Club.

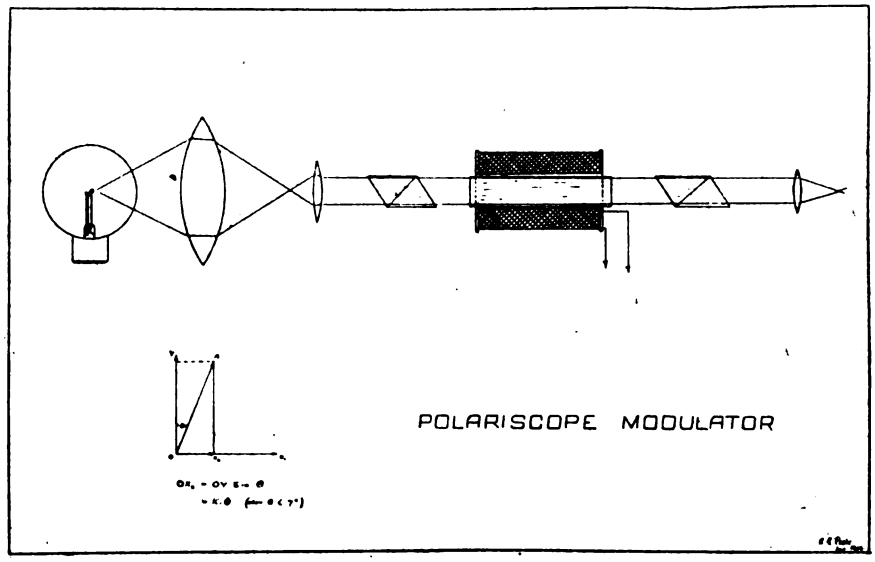

Fig. 10.

Polariscope Modulator.

Intense beam of parallel light is polarised by first Nicol prism in the direction OY on vector diagram. The second Nicol is set with its principal plane in the direction OX, so no light passes until the plane of polarisation is rotated by passing through the magnetic field in the tube of CS_2.

The Annual Meeting and Exhibition.

So much for the past; we now turn to the future. The annual meeting and exhibition takes place on Tuesday, March 5th, and promises to be a much more important occasion than we had anticipated. We are told at Headquarters that offers of apparatus are coming in well, and that members are responding to the invitation to help themselves by returning the "Buff Form." Over

(*Continued overleaf, col.* 3.)

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The First Television Subject

By W. TAYNTON

W. TAYNTON.
The first face ever seen by Television.

In the following article Mr. Taynton, who was the first man in the history of the world to be televised, describes in his own words this epoch-making event.

I REMEMBER very clearly how one afternoon while I was working in Mr. Cross's office in Frith Street, Mr. Baird, who had his laboratory above us, came running downstairs in a very excited condition, and almost pushed me in front of him into the laboratory and got me to sit in front of his projection lamps. These were enormous electric bulbs, and gave out a tremendous amount of heat. Behind the lamps there was a whirling disc, and behind that again a quantity of wireless apparatus.

After I had sat down Mr. Baird went into the next room where the receiving machine was, and left me in front of the lights. Without realising that I was spoiling the experiment, I moved back a little way to avoid the glare and heat. After about five minutes Mr. Baird returned, and the moment he saw me he said: "Ah! Why did you go back?—that explains it—you must keep exactly where I put you."

Knowing what was required, I did not move this time, and held on as long as I could. I was just beginning to feel I could not keep still any longer, when I heard a shout from the next room, "Open your mouth." I did this, and was then told to turn sideways, and this was followed by Mr. Baird's sudden return to the transmitter, saying: "William, I saw you; would you like to see what television looks like?"

Mr. Baird seemed very excited, and took me through into the other room, where I looked through a little square opening at the face of a revolving plate. The square seemed covered with a reddish light.

A minute or two later Mr. Baird went into the other room, and on a little screen his face immediately appeared. It was not very clear, but by looking closely I could see his eyes and I could see his mouth open and close, and recognise that it was Mr. Baird himself.

Although I did not realise it at the time, I was the first man in the world whose face had been transmitted by television, and the second man to have seen a televised human face.

I must say I did not then realise the marvel I was witnessing, but thought it had a very long way to go before it could compete with the cinematograph.

It was while I was with Messrs. Will Day, Ltd., of Lisle Street, Leicester Square, that I was kindly invited by Lord Angus Kennedy to see a demonstration at the Olympia Radio Exhibition in September last. On my arrival I was shown to the compartment where the demonstration was being held, and I can only say that I was not prepared for the wonderful improvement.

Things have moved rapidly since that memorable autumn day in 1925, and now television is talked about wherever one goes. But in those days nobody had heard of it, and Mr. Baird, whose name is now so well known, then worked alone in complete obscurity in a little two-roomed laboratory in the back streets of Soho.

The Television Society.

(*Concluded from page* 37.)

eighty of these questionnaires have already got back to Belgrave Road.

Apart from what our members are doing in connection with the Exhibition, two or three firms have promised to show pieces of apparatus of special interest, and other friends of the Society are helping in various ways. We might mention among the latter that Mr. Lloyd B. Atkinson, past-President of the Institute of Electrical Engineers, is showing some early historical "relics" with which he experimented on television over twenty years ago. Mr. Atkinson is explaining the working of the different parts, which will afford added interest to this exhibit.

The Exhibition, which opens at 7.30 p.m. on the evening of March 5th, will be preceded at 6 p.m. by a business meeting, to which only those who are fully elected members of the Society are entitled to be present and to vote.

It is hoped that members will always wear their badges at meetings of the Society; these may be obtained from Headquarters, price 1*s*. each.

We have just learned that our President, Dr. Fleming, has now returned from a ten weeks' tour in Egypt, looking very fit and well.

Official Notices.

The next meeting of the Society will take place at the Engineers Club, Coventry Street, London, W.1, on Tuesday, March 5th.

The Annual General Meeting will be held at 6 p.m. It is hoped that all members of the Society who are entitled to vote will be present at this business meeting, which is convened to receive the report of the Council and to proceed with the election of officers.

An exhibition of apparatus will take place in the same building and will be opened to members and their friends (on invitations to be obtained from the Secretaries at 95, Belgrave Road, Westminster, S.W.1) at 7.30 p.m. The meeting will be of an informal character, but it is important that the Secretaries should be informed of the members attending the Exhibition. Coffee and light refreshments will be served.

J. J. DENTON,
W. G. W. MITCHELL,
Joint Hon. Secretaries.

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LUMINESCENCE

By H. WOLFSON

In the following article our contributor deals in detail with the various forms of radiation which manifest themselves visibly in the form of light which is not associated with heat.

MANY of the facts which we have learned from a study of photo-electric phenomena have a close bearing on the ideas connected with the subject of luminescence.

Under the general heading of luminescence, which was suggested in the first instance by Wiedemann, we include all those cases where light is emitted in the absence of heat. It is convenient to subdivide the subject into five groups, viz. :—

1. *Tribo-luminescence*, by which we mean the emission of light due to friction or crushing, such as is observed by rubbing together crystals of sugar, quartz, etc.

2. *Cryo-luminescence*. Here the light is emitted during the crystallisation of certain salts from solution.

3. *Chemi-luminescence*. This refers to light generated by chemical action.

4. *Electro-luminescence*. This term is applied to all cases where the light is excited by such causes as cathode rays, X-rays, positive rays, and by radio-active substances.

5. *Photo-luminescence*. This group which includes fluorescence and phosphorescence, deals with the emission of light under the action of light, and will be considered in detail in this article.

Displacement of Electrons.

It is important that we should realise at the outset that the removal or displacement of electrons from the luminescent substance must be a very large factor in the process which takes place when light is emitted. In all the five groups we can see clear evidence on this point; thus Group 1 would seem to point to the existence of frictional electricity in a system such as described, while the displacement of one or more valency electrons, such as would occur in chemical changes which involved the breaking of a "bond," leads us to similar conclusions. Further strong support is given by a consideration of the phenomena in Group 4, where it becomes evident at once that the fluorescence of the glass of cathode ray tubes, and the apparent incandescence of certain crystals when subjected to cathode rays* can only be explained on the assumption that electrons are displaced from the atoms of the glass or crystals.

Confining our attention more closely to the last group, it will be convenient to mention now the difference between the two types of photo-luminescence. By fluorescence we imply the emission of light which commences and ceases with the stimulus, whereas luminescence which continues after the stimulus (light) has ceased, is termed phosphorescence. This latter type of luminescence is shown only by luminescent *solids*, while liquids and vapours which fluoresce never continue to emit light after the stimulus has been withdrawn.

As early as 1845 Herschel noticed the blue colour which is shown by solutions of quinine sulphate, and in the following year Brewster recorded his observation of the blood-red colour which he noticed when a beam of light was passed through a solution of green chlorophyll in alcohol.

The general name of fluorescence was first applied by Stokes, who seems to have been the first to realise the importance and interest of a detailed and careful experimental study of the subject.

The method employed by Stokes consisted of examining the substance in different parts of the spectrum. With quinine sulphate and other similar solutions, he found evidence of the activity of ultra-violet rays in producing fluorescence. By a series of investigations on the degree of refraction of the emitted light as compared with that which was incident upon the solution, he suggested a law, which has since been modified so as to be perfectly general. Nichols and Merritt, whose work deserves special mention, state Stokes' law in the following words: "Luminescence is due to an absorption band. The absorption band and the luminescence spectrum overlap, and all waves included in the absorption band can produce excitation. In luminescent bodies the maximum intensity for a given substance is fixed as to wave-length, and is independent of the intensity and of the character of the stimulus."

*TELEVISION, January 1929, p. 20.

Phosphorescence.

This form of the law is more exact than Stokes' original law, which held that the wave-length of the rays emitted by a fluorescent solution was always greater than the wave-length of the exciting light.

Phosphorescence is supposed to exist only in what are termed solid solutions, that is, a solid with which is crystallised some other substance, with which it is isomorphous. This other substance may be, and usually is, present as an impurity, and an amazingly small proportion is sufficient to produce phosphorescence. Well-known examples of this are given by the sulphides of metals of the calcium, strontium, and barium group. While pure calcium and barium sulphides show no luminescence, the commercial samples, which contain but minute traces of other elements, such as zinc, bismuth, manganese, etc., have been known for several centuries, under the names "Canton's Phosphorus" and "Bolognian Phosphorus," respectively.

A number of workers have examined the fluorescence of sodium vapour, and have observed spectra of a complicated character. There seem to be groups of spectral lines in the fluorescent light which are associated with one definite frequency of the radiation which excites the luminescence.

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Onnes and the Becquerels have examined the spectrum of phosphorescent light at extremely low temperatures, which have been obtained by the use of liquid hydrogen and liquid helium, thanks to the brilliant researches of Onnes, the Dutch expert on low temperature research. At these temperatures it was found that the luminescence spectra of salts of uranium, which at ordinary temperatures consisted of broad bands, consisted of very fine lines. On plotting curves of intensity to wave-length of light they found that the graphs corresponded with the energy distribution curves for ordinary luminescence.

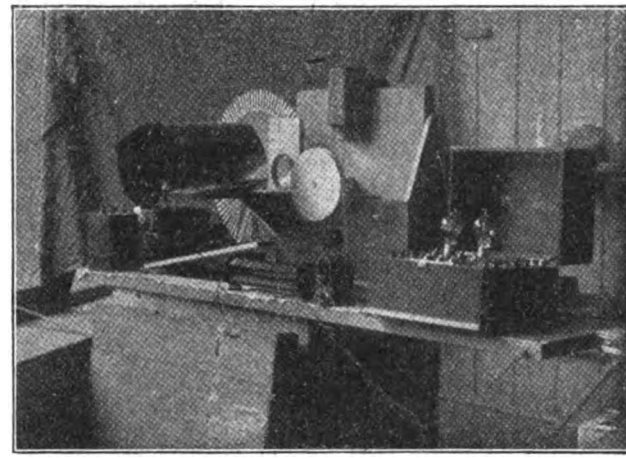
Lenard and Saeland observed a phenomenon, which they termed the "actino-dielectric" effect, while working with luminescent sulphides. This effect consists of a type of photo-electric conductivity, for when the substance was illuminated with light containing a red component, and was maintained at a positive potential, the galvanometer gave a deflection, which increased to a maximum and remained constant. With the specimen maintained at a negative potential the deflection continued to increase as long as the specimen remained illuminated. When the specimen was exposed for long to the red light it exhibited a form of fatigue, and would not show the effect for several hours. If the substance was made alternately positive and negative there was no tendency to fatigue.

Gudden and Pohl have found an increase in the dielectric constant of zinc sulphide (natural Sidot blende) when exposed to light, and they have also shown that certain phosphorescent materials increase their conductivity when illuminated, though electric fields of the order of 3,000 volts per cm. are necessary to bring about the conductivity change. They plotted graphs in which the effect was shown as a function of the wave-length; the curve has a well-defined maximum and resembles the curves for the selective effect in the alkali metal cells.* With weaker fields the curve assumes a shape similar to the normal photo-electric effect. They have assumed that the electrons emitted in the selective effect have not sufficient velocity to obtain the full freedom necessary to act as conduction electrons. The strong electric field enables them to obtain this power. The same workers found that, in accordance with this view, a strong electric field applied to the blende during decay of phosphorescence caused a sudden increase in luminescence, followed by a more rapid decay than before the application of the field. It was also noted that there was an increase in conductivity after the original excitation had disappeared, if a beam of red light fell on the cell.

*TELEVISION, September 1928, p. 14.

Stark's Theory.

We must now consider the various theories of luminescence. That due to Stark is of special importance, and will be discussed first. He imagines



BAIRD TELEVISOR—1924 MODEL.

a limited number of valency electrons on the surface of the atom, which can of course become detached from the surface. As we have seen in previous discussions, these valency electrons may leave one atom, and become attached to others. This explains the formation of positive and negative ions, as in ionisation by collision, which we discussed last month. According to Stark's view, the valency electrons form the characteristic band spectra, and that the carrier of the band spectrum is a molecule composed of several atoms.

The carriers in the case of the line or series spectrum are single atoms which have lost valency electrons, and are thus positive ions. Fluorescence or phosphorescence which is connected with band spectra is supposed to be that emission of light accompanying the restoration of valency electrons. The difference between the two is not basic, but dependent only on the time during which the separation of the electron continues. With fluorescence this time is an infinitesimal quantity, with phosphorescence, a finite quantity, depending on the electrons of which the material is composed.

Phosphorescence is thus bound up with photo-electric emission, while fluorescence does not necessarily imply photo-electric activity; in general, however, there is an associated photo-activity. This theory accounts for the difference in frequency between the incident and the fluorescent light, discovered by Stokes. Einstein has expressed Stokes's law mathematically. If ν_a is the frequency of the exciting light and ν_f that of the fluorescent light, the energy of the carriers will be $h\nu_a$. This energy is imparted to the electron, and the available emission energy in the restoration of valency electrons cannot exceed this.

Thus $h\nu_f \leq h\nu_a$ so that $\nu_a > \nu_f$, which is the same as $\lambda_a < \lambda_f$, the wave-length of the activating light is smaller than that of the fluorescent light.

Stark recognises short-wave and long-wave bands. In the former the intensity of absorption and emission diminishes as one passes from short to long wave-lengths. In long-wave bands the intensity increases in passing from long to short wave-lengths. The two are dynamically coupled, so that the emission of one is accompanied by an emission of the other. Fluorescence and photo-electric effect are closely connected with the absorption bands towards the red, for when light is absorbed in such a short-wave band it excites fluorescence both in the short and the coupled long-wave band. Absorption of light in long-wave bands approaching the ultra-violet, results in neither fluorescence nor photo-electric effect.

Lenard and Saeland, whom I have already mentioned, connect phosphorescence with the photo-electric effect. Substances such as sulphides of calcium, etc., which are usually good insulators, emit electrons under the influence of light, acquire a positive charge, and thus neutralise to some extent the external field which is applied with a view to measuring the photo-electric activity.

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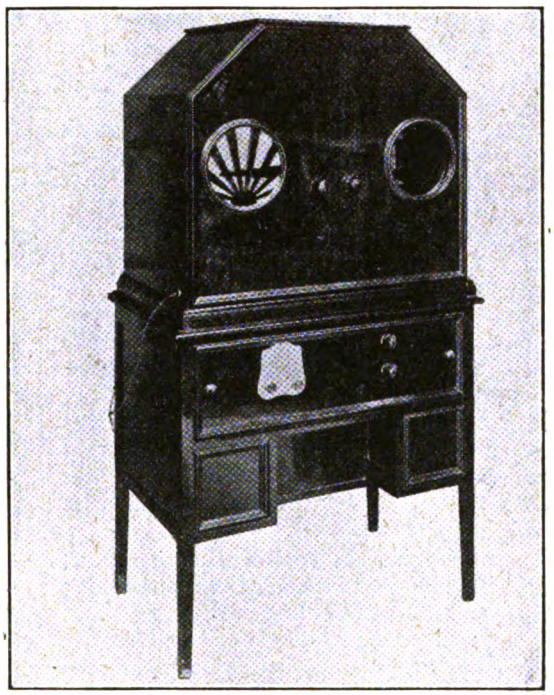
The photo-electric effect is assumed to be concentrated at certain molecular groups or centres. Under the influence of light there is an emission of electrons from the metal atoms of these groups, which become thereby positively charged. The liberated electrons are either captured by sulphur atoms or scattered among the surrounding atoms unattached. Whenever a recombination takes place between the centres and the electrons, phosphorescence is stimulated, for he holds that when *photo-electrons* return to the atom *emission* electrons are caused to vibrate, and thus emit radiation.

Considering the variation with temperature, Lenard concluded that for each band in the spectrum of a body there is a certain range of temperature corresponding to phosphorescence, above and below which there is little or no phosphorescence. By increasing the temperature the collisions are made to occur more frequently, and the electrons can return more easily to the atom. The action of infra-red and red radiation is supposed to have a similar effect, and set in motion larger aggregates, consisting of sulphur atoms with attached electrons by resonance; the free period of the aggregates being large, they respond readily to long waves. This increase in the number of collisions causes a momentary increase in phosphorescence, and at the same time makes the decay more rapid.

Lenard has a very reasonable explanation of Stokes's law. When a photo-electron returns to the atom it is caused to vibrate with a large, but continually decreasing, amplitude. The period decreases with the decrease of amplitude, so that the photo-electron can only cause excitation of the emission electron when its frequency has become identical with that of the emission electron, and can thus cause resonance. The photo-electron can thus bring about emission only when it has finally a smaller frequency than the emission electron. This means that the frequency of the exciting light which releases the photo-electron must be greater than the frequency of the phosphorescent light. (Or the wave-length must be less.)

Lenard distinguishes between three different processes in the decay of phosphorescence: (*a*) The short "Momentanprozess" or m-process which obeys a logarithmic decay law, and which is observed when the exposure to the spectrum is of very short duration. (*b*) The more lasting "Dauerprozess," called in England the d-process, in which the intensity varies inversely as $(c+at)^2$, where t represents the time of excitation, usually of a few minutes' duration. (*c*) The third or u-process is brought about by the action of ultra-violet radiation. Without going deeply into the mathematics of the subject, it must suffice here for me to mention that in many cases the intensity of phosphorescence I can be represented



BAIRD TELEVISOR—1928 MODEL.

by the formula $I=\frac{a}{(c+at)^2}$, t being the time and a and c are constants.

Other workers have shown that there was no photo-electric effect corresponding to the m-process, which shows that no electrons are emitted from the luminous centre in fluorescence (m-process).

Other less important theories have been suggested by workers such as the resonance theory of Lommel, but though this in part explains Stokes's law, there are innumerable difficulties both practical and theoretical which make its acceptance impossible.

Wiedemann has brought forward additional hypotheses in order to assist the theory, and suggests that the fluorescing molecule is capable of existing in several conditions. Under the influence of light a transformation may take place from state A to state B, and fluorescence may occur either in change from A to B or in retransformation from B to A. This transformation may be either chemical change, intra-molecular rearrangement, or an ionisation. This idea supports Nichols and Merritt's suggestion that excitation produces an electrolytic dissociation of the active substance, and that luminescence results from vibrations set up by dissociation or association of the ions.

In the future development of the theory of luminescence, it seems highly probable that it will be necessary to make fuller use of the quantum theory. Space does not permit that I should develop this idea, and, indeed, it would be difficult to do so without first acquainting the reader with the modern conceptions of atomic structure and a simplified view of the quantum theory. In completion, therefore, I will ask those of my readers who are unacquainted with this theory to bear with me but a few moments; a complete understanding of the following will be forthcoming when they know more of the mysteries of the atom.

Baly has shown that there is a relation between absorption and luminescence bands and their arrangement in series. The equations which he obtained can represent with great accuracy the frequency of the bands. Thus $\nu=K\nu_0\pm mb$, k and m are both whole numbers and ν_0 is the frequency of an infra-red band. The symbol b is called the basis constant. In certain cases there may be two basis constants, which are supposed to be related to the moment of inertia of the rotating molecule.

I trust that this short dissertation has brought to the notice of readers the existence of yet another branch of the subject of light and photo-electricity, that it may be the means of stimulating still further researches into its mysteries, and that it may deepen the understanding and realisation of the wonders of the Infinite.

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The Televisor Solves a Mystery

By EDWARD J. DUTTON

SIR WYNDHAM RUDD was worried. As he sat in his library at his house in Curzon Street his eye glanced round at numerous little wall cabinets that occupied spaces between the sets of bookshelves. In those cabinets reposed the most magnificent collection of rubies in the world. The Rudd Collection was famous and unique.

For several days past certain peculiar events had caused the collector a vague uneasiness. Now that uneasiness had developed into a concrete fear. Of course, he reflected, the rubies were insured for a very respectable sum, but no amount of insurance could recompense him for the loss of certain of his gems; they were irreplaceable.

The happenings that had caused the baronet a sense of irritation were not in themselves suspicious. In fact, even now, when his trained mind told him that all these little things added together made one suspicious whole, he was inclined to laugh at his own fears and put them down to a slightly torpid liver.

But, as he told himself, it would never do to take the risk of remaining inactive in the face of his discoveries.

It had started a week ago, this chain of unaccountable things. In the first place a dirty footprint had been found on the pale ground of the pile carpet immediately in front of one of his cabinets. Nothing, apparently, had been disturbed, and there were no other imprints elsewhere; merely this impression of a male boot or shoe.

The same night the butler, locking up, had discovered the lock of a small, little-used door at the rear of the house had been tampered with. It was replaced. Two days later the new lock was found to have been carefully unscrewed, false screwheads placed in all the holes except one, in which the original screw had been loosened so that a mere push would have opened the door with perfect ease.

Yesterday, on going to his cabinets, Sir Wyndham had found that an effort had been made to hide certain scratches on one of the panels with new polish. That the scratches had not been there the previous day the collector was certain. Someone had tampered with the case.

Sir Wyndham gazed thoughtfully at his diary in which he had recorded these happenings. Who could be responsible for them? They bore every indication of being the work of some amateur thief. And yet, they were so patently obvious that they might well be intended to throw dust in his eyes. A sort of criminal red-herring to hide some more subtle move of a clever gang.

His mind ran over the inmates of his household: His wife, a *grande dame* of the old school, whose caustic wit and clever epigrams made her the lioness of the big social functions which she graced. She could be ruled out. Mavis, his daughter, a brighter replica of her mother, was likewise off the list.

Dakin, his confidential secretary, seemed all that such a one should be; a tall, straight-limbed, clear-eyed, clean-living youngster, whose past life Sir Wyndham had probed into with scrupulous care before engaging him for the post.

There remained only Scott, his butler, and Ellen, the housemaid. These were the only two of the indoor staff of servants whose duties brought them to the library.

Sir Wyndham tapped his teeth with his pencil as he closed the book. He would have liked to have discussed this problem with somebody, he thought. Somebody who could understand. A fellow collector for choice; old Baumstein, for instance.

Baumstein wouldn't sympathise, though. Jealous old fox. Just because he had outbid him for one or two prize gems at various times. Wonderful pieces, which Baumstein had coveted with the covetous greed that can overcome even the most level-headed of collectors. Sir Wyndham chuckled: "No! no use taking my worries to Baumstein; he'd just secretly rejoice."

With a look of sudden decision in his eyes he rose and pressed a bell.

To Ellen, who answered his ring, he spoke more sharply than was his wont, causing the girl's eyes to widen in slight astonishment. As a rule the master was courtesy and consideration themselves for his servants, and they all worshipped him for it.

"Tell Jones to bring the car round at once. I am going to Scotland Yard." He looked deeply into the wide clear eyes before him, but if he hoped to surprise a look of guilt or fear there he was disappointed. All he saw was respect and a mild reproach. With a murmured "Yes, Sir," the girl went out and the baronet cursed himself for a fool.

* * *

The grim, grey buildings by the Embankment which house the most efficient criminal investigating machine in the world, seemed awe-inspiring to Sir Wyndham Rudd on this, his first visit, as he stepped into the reception hall. These tall, keen-eyed men, who continually passed in and out, gave him a feeling of diffidence. He sent his name up to the Assistant Commissioner, who was a fellow club-member of the Pythagoras.

The room into which he was ushered was large and airy, but its furnishings were clearly designed more for utility than for comfort. A couple of roll-top desks with their attendant deep-backed chairs, a long filing cabinet, a huge map of the British Isles on the wall, and three or four leather-seated, Windsor-type chairs comprised the equipment.

At the desk against the fireplace sat Major Dalton, the Assistant Commissioner of Police. A hawk-faced man of thirty-five, with a military moustache, and the unmistakable bearing of one born to command. In a far corner, a white-haired

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individual was doing something with several boxes and pieces of wire. He took no notice of the new-comer, and Sir Wyndham, after a curious glance, went forward to meet his friend.

"Well, well, Sir Wyndham, what brings you to this den of iniquity?"

"In a far corner a white-haired individual was doing something with several boxes and pieces of wire."

smiled Dalton, as he shook hands. Rudd drew forward a chair and, placing his hat and stick on the floor, recounted his suspicions to the man whose name had power to put the fear of God into every criminal in Europe.

"I am pretty sure," he concluded, "that an attempt of some sort is being made to steal my rubies. I wish you could give me some assistance to catch the person responsible."

Dalton nodded gravely. "Right," he said, "I will send one of our best men along to your place this evening. But .... hold on a moment," he glanced thoughtfully over to the man in the corner.

"Drew," he called, and the white-haired stranger ambled over to the desk.

"This is Sir Wyndham Rudd, Drew. Someone is trying to pinch his collection of rubies. I've got an idea this is the opportunity you have been asking for." He turned to Rudd: "Meet Professor Drew of the National Television Laboratory," he said.

The baronet found himself shaking a cold, lifeless hand, and looking into a pair of pale, dreamy eyes, behind which, however, there gleamed the fires of genius. He had heard much of the remarkable discoveries in the new science of television, due in great measure to the indefatigable research work of this odd-looking man.

Dalton repeated all that Rudd had told him for the information of the Professor and waited, a query in his eyes.

"Yes, yes," concurred the grave voice of the scientist. "Whatever is done to try and catch this mysterious person red-handed must be done secretly. On no account must anyone, not even the members of Sir Wyndham's own family, know what is being arranged."

"That is so," agreed Dalton. "From evidence which Sir Wyndham has given me I am inclined to the belief that it is what we call an inside job, that it is someone inside the house who is the culprit, or who is in league with the actual thief. The tampering with the lock on the back door is merely a blind."

"Then you think you can help me, Dalton?" queried the baronet, in relieved tones.

"I think Drew will certainly be able to help you," replied the Major. "And at the same time prove the utility of his latest invention in the detection and prevention of crime."

Rudd looked his mystification.

"Perhaps it would be as well if I explained," suggested the television expert, mildly.

"I daresay you are aware," he proceeded, "that, so far, television has advanced to the point when a regular service can be received, on quite small portable television receivers, broadcast from a main transmitting station which is housed in one building, and consists of a quantity of cumbersome plant with massive aerials and other heavy gear.

"My latest discovery is a step ahead of this. It consists of a small, portable transmitting station which can be carried about from place to place, and, so long as my Electric Eye can see the scene, will faithfully transmit to an ordinary receiver whatever is in front of it.

"As an aid in the detection of crime it will, I am sure, prove invaluable. Placed on standards where crowds congregate, pickpockets will be detected in the act by the Electric Eye. Fixed wherever there is danger of a theft being committed, as in your case, it will record the whole crime to a watcher at the receiver. The criminal will be identified, and can be arrested as he leaves the place with the goods on him."

Sir Wyndham smiled his approval. "And there is no danger of its presence being suspected?" he asked.

"None whatever," replied the inventor. He shuffled with his curious ambling gait over to his boxes. "See," he said, returning, in one hand an ordinary suitcase, and in the other what appeared to be a small travelling clock. "In this case is the actual transmitter. This can be attached to the house lighting circuit, or run off batteries inside the case."

He placed the case on the floor in front of the desk. The clock-like apparatus he held up for Sir Wyndham's inspection. Now the baronet saw that the glass front of this object was really a thick lens. Professor Drew pressed a catch, and swung the front open. "Behind this lens," he explained, "is the rotating scanning disc turned by means of a very small electric motor. In each of the spiral apertures there is a special double-roof prism of my own design, the two long faces of this prism being made up of four inclined faces which meet in twin median ridges at an angle of ninety degrees.

"As the light emanations from the subject are reflected through the front lens they are picked up by these prisms, which reflect the rays impinged on their faces and pass

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them out, with double their original intensity, on to a bank of photo-electric cells, whence they are emitted as sound waves to the transmitter in the suitcase which, in its turn, sends them out to be picked up by the receiver.

"You will observe that this Electric Eye is no bigger than an ordinary microphone, but it is, believe me, extremely sensitive. It can be placed on the mantelpiece or on top of a cabinet, and connected to the transmitter by these two lengths of twin flex wire."

Sir Wyndham looked on with astonishment, whilst Major Dalton smiled tolerantly at the enthusiastic and permissible note of pride in the inventor's voice. Half an hour later Rudd left the Yard with the Professor's wonderful suitcase and the Electric Eye riding safely beside him on the seat of his car.

* * *

Outside the library window of the house in Curzon Street the star-spangled sky was veiled at times by scurrying wisps of cloud. From below, a dull glare came from a street lamp a few yards away.

Inside the room the darkness was tinged with grey, so that the furniture took on queer, black shapes, and assumed terrifying proportions. In the corners farthest from the window the blackness was intense. Not a sound broke the stillness of the night.

In his bedroom, Sir Wyndham Rudd, aquiver with excitement, sat before the standard television receiver that he had surreptitiously brought upstairs from the drawing room earlier in the night. He had managed to make the necessary arrangements without a soul in the house being one whit the wiser: one Electric Eye opposite the door at the rear of the house; another one to one side of the window of the library, so that it commanded a practically complete view of the room. Lengths of twin cable laid carefully under linoleum and carpets led from each Electric Eye to the Professor's suitcase, ensconced under a large easy chair. Everything was ready.

He had arranged to ring up Dalton at the Yard as soon as the thief made his appearance. Dalton had a Flying Squad van in readiness to rush round to Curzon Street should it be needed.

Some sort of intuition told Rudd that an attempt on the actual theft would be made to-night. He looked into the screen of his televisor, and pulled the 'phone nearer. He had already put out the lights in his bedroom so that now the whole house should be in darkness.

His mind ran over the inmates of the house again. Lady Rudd had been to a bridge party that night, returning an hour and a half ago, and retired to her own room. His daughter had elected to stay at home. He smiled at the thought that this mystery would have pleased her mightily, for she was an omnivorous reader of detective stories.

Dakin, the secretary, had been out but had come in fairly early, and Sir Wyndham had not seen him since about ten o'clock.

The butler and the rest of the staff were away in their own part of the house, and the baronet had made sure of locking the communicating door before he retired himself.

"How old Baumstein would chortle if he knew," thought Rudd, grinning ruefully to himself in the dark. A clock, somewhere, struck two, and the watcher checked it with the watch on his wrist.

Suddenly, in the screen of the televisor, a flickering shadow crept across the glass. Sir Wyndham, with a hand that trembled from pure excitement, took a cigarette from a box on the table and lit up; he found it steadied his nerves.

The vision in the screen had become clearer now, and he could see the back door plainly. Someone had broken the thread which started the transmitting mechanism, and bathed the scene in invisible infra-red rays. Slowly the door opened and a figure, indistinct against the shadow of the outer porch, slipped smartly inside, closed the door, and stood listening. The scene faded as the intruder passed up the passage towards the library.

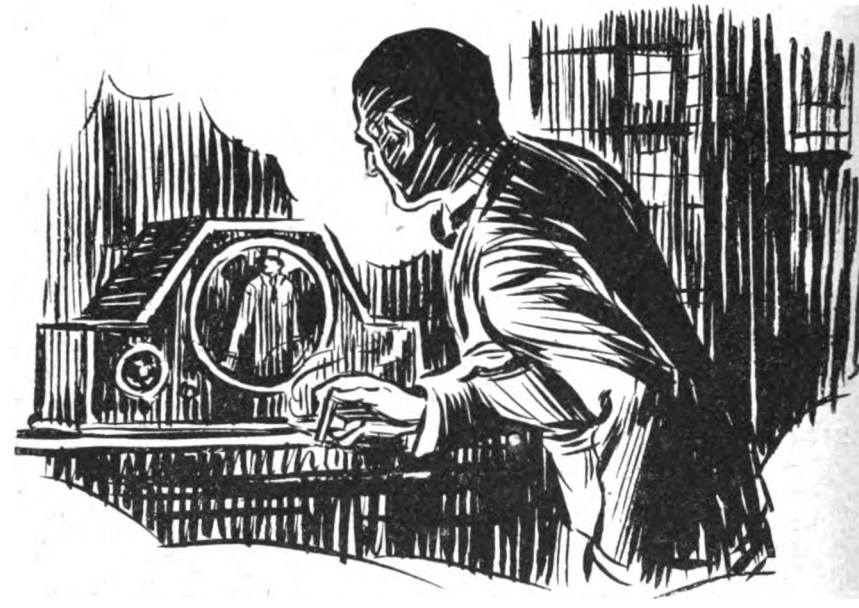
Sir Wyndham unhooked the receiver. Within a minute he had spoken to Dalton and had been assured that the Flying Squad was on its way. Again he looked into the televisor.

The opening of the library door snapped the thread operating the second Eye, so that now he could see the room containing his precious rubies as though he were standing by the window himself.

Over against the cabinet which housed the pick of his collection the figure of the mysterious marauder crouched, working at the lock with some instrument. Sir Wyndham watched, grimly smiling at the surprise in store for the spoiler, content to wait and watch while Dalton and his merry men made their arrest.

Outside so that it might, or might not, have been a car stopping, a slight screech sounded. It had not reached the ears of the man downstairs, who still probed at the case with his back to the inquisitive Eye that watched his every movement.

Then, in the doorway, men



"Suddenly, in the screen of the televisor, a flickering shadow crept across the glass . . . . . slowly the door opened and a figure . . . . . slipped smartly inside."

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appeared. Silently, with Dalton at their head—keen-eyed, grim-mouthed men, whom nothing baulked.

Rudd dashed for the stairs. He wanted to be in at the death. When he reached the library the detectives had got the fellow, and he now sat on one of the chairs, his manacled hands to his face, head between his knees, broken, finished.

Something about the figure—the shape of the grey, bowed head, now that the hat was off—seemed vaguely familiar to Rudd.

Then the man looked up and stared at the baronet with dazed eyes.

"Baumstein!" gasped Rudd, incredulously.

The figure in the chair groaned, then: "Tamn you, Rudd. Always you rob me. Rob me of the treasures that I set my heart on. The peautiful rubies, like drops of liquid fire. Always for the best ones you, mit your great wealth, outbid me. Me, I cannot afford to go so high . . . and so . . . I lose. And then I come . . . I cannot resist. I want one of your peautiful ones for myself . . . to put in my collection . . . to feast my eyes on it every day. And now . . . I am a felon. A tief . . . I shall go to the prison. Never more shall I see the lovely jewels. . . ." The voice of the old man broke off into convulsive sobbing.

Rudd looked at him with troubled eyes. Then he spoke to Dalton in a low tone. At a sign from their chief the Yard men left the room. Then Dalton addressed the moaning creature in the chair.

"Baumstein, listen to me. Sir Wyndham declines to prosecute you for this night's work. As a fellow-collector he feels that he knows you were only actuated by your jealousy. I think that is very handsome of him. In the eyes of the law you are a thief, Baumstein, and I'm not sure that I'm not compounding a felony in agreeing to let you go. Anyway, I think this should be a lesson to you to curb your covetous acquisitiveness in the future." He took the handcuffs off and followed his men.

Baumstein looked up at Rudd as the door closed behind the Assistant Commissioner. "My friendt . . . how . . . how can I thank you?"

Rudd smiled his genial smile as he patted the old man's bent shoulder.

"That's alright, Baumstein," he said, easily. "Come round to-morrow and tell me what you think of my new nickel-steel cabinets."

IF I WERE JOHN BAIRD

By NÖEL SWANNE

"*If you were Mr. Baird . . .*" began Marjorie, and paused.

* * *

I must have a wonderful mind, because the number of things I thought of during that short pause would, if placed end to end, be as long as a grandfather cod-fish weighs ounces.

If I were Mr. Baird. . . . Well, of course, to begin with, I should have a little holiday. I should feel that I deserved it. When I got back . . . perhaps I might never come back. You know, these millionaire people can have those holidays of the never-come-back type.

I have been told that Mr. Baird is not a millionaire, but it is hard to believe. The man who sells me nice, fresh cauliflowers picked that very morning from the pile of stuff left over from the week before last, spends his Sundays in a most beautiful limousine. He never says "Sir" to me when he passes my baby car. Now the relative merits of cauliflowers and television is as the square root of a Kontinuum is to a far-parallelism, as Mr. Einstein would say.

Anyway, if I did get back, I should have a jolly good rest. I should probably come back on a Tuesday and I should not invent anything for two whole months, and then I should invent something that a woman can smear on her face. That's the way to make money. Never mind about television.

Then I should have another little holiday to get over the strain, and when I got back I should pal up with a marquis. Dukes and earls are all right as far as I know, but give me a marquis every time. It sounds so good. The word conjures up the delicacy of mediæval colour and manners. One fancies one hears the click of rapiers, and sees the sunlight glancing off their keen points. I should choose a marquis who began life as a butcher.

You see the connection? Get the best society interested. Can't you see the reporters rushing along, and an army of press-photographers lining up. Then to-morrow the purple press comes out in spots, which you recognise as a picture of the Marchioness using her private televisor to watch her children chopping up a dead dog. (Article by Professor Wottle on literary page on "The Influence of Heredity.")

Mrs. Booker, of Tooting, will immediately look up the stores catalogue and see what televisors cost, and order two . . . the thing is done with then. As far as I can see, there would be nothing more to do but go away to Brighton and sign receipts.

One couldn't just leave it at that. After a time I should put up the price of televisors, and let the world know what Mr. Everyman thought of my methods and my plain cases. I should also add a few useful gadgets to the thing, such as replacing the front panel by a neat little shaving mirror, and a device on the right into which one slips a penny and gets a hot drink—American models would just be the case, with all the television stuff taken out of it, fitted up with convenient places for storing bottles.

It would then be a really brilliant step to call on the B.B.C. and tell them about television. Joking apart, I think they ought to know something about it. Another long holiday would then be necessary to get over the strain—"but don't you see, Mr. Eckersley, the interference of the scanning device will heterodyne the immobile inductance by an amount equal to $\pi^3\sqrt{y}x^4_{23}$ and so the . . . Well, anyhow it is all dam silly." Fancy keeping that sort of stuff up for long!

By this time the face cream, the shaving mirror, and the hot-drink business should be coming home nicely, and one could give up worrying about television. After all, who wants television? Everybody, of course. Well, they can't have it, and that is very good for them. My grandmother used to take cake away from me for the same reason, and she lived to be eighty-three. I wonder if Mr. Baird wants to live to be eighty-three? It's a great age.

One can't go on thinking about things deeply in this manner without evolving in the end some great thought which illuminates all that was hitherto dark, and at this stage of my ruminations there came into my mind the glimmer of such a thought as Aristotle, Galileo, Newton, or Mrs. Meyrick had never thought, but Marjorie interrupted me . . .

* * *

"*. . . television would never have got so far ahead as it has,*" she concluded.

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The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. each.

SELENIUM CELLS.—Progress in the design of these cells continues steadily. Even now they possess a degree of reliability which places them in serious competition with the less robust photo-electric cell, in such practical applications as burglar alarms and in some systems of sound production in conjunction with "talking films."

Their future usefulness in television systems is very largely dependent on improvements which can be made to overcome, or at least to minimise, parasitic noises emanating from within the cell itself. On the further question of the delayed action of selenium cells, which is commonly called "time-lag," it is to be understood that, provided the so-called "lag" is a constant for all working values, this in itself is not a serious defect.

Patent No. 300183 has recently been granted to J. L. Baird and the Baird Television Development Co. It is claimed that by the particular construction employed loss of light through reflection is reduced to a minimum. At the same time those changes of resistance due to light falling upon the cell, as well as changes of resistance due to temperature change within the cell, are both made to act in the same sense.

FIG.1

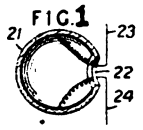
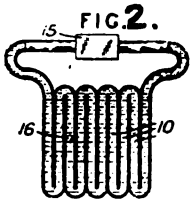


FIG.2.

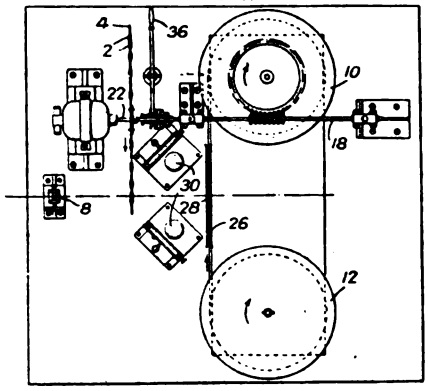


In order to eliminate loss of light by reflection the selenium or thallium sulphide forms a thin coating on the inside of a chamber (21) in Fig. 1, which is closed except for the window (22). Leading-in wires (23) (24) are connected to diametrically opposite points in the film.

In an alternative arrangement the chamber is made of metal, coated internally with selenium, and filled with a transparent electrically conducting fluid. One electrode is immersed in the fluid and the other is constituted by the casing.

Now if the mean temperature of the selenium or other light-sensitive film is suitably chosen, the change of resistance with temperature is added to the change of resistance due to light falling on the cell. In order, therefore, to secure a suitable working temperature within the cell, the latter may be completely immersed in a water jacket provided with a heating coil. According to the provisional specification

FIG.3.



the cell may be enclosed in a vacuum or an atmosphere of inert gas.

A novel form of *liquid exploring device* is the subject of a *Patent No.* 299402, recently granted to J. L. Baird and the Baird Television Development Co. A bubble of gas (16) is made to circulate through an opaque liquid contained within a set of tubes (10). These tubes are arranged side by side as shown in Fig. 2 to form an exploring screen, and circulation of the transparent gas bubble is brought about by means of a pump (15), so that as the bubble traverses the tubes (which are arranged in series) the object is explored by light passing through the bubble.

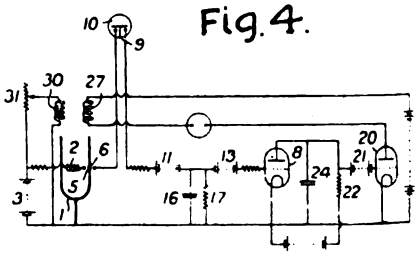
At the receiver a number of insulated electric conductors communicate with the interior of the tubes, which contain conducting liquid. An electric potential, varying in accordance with the incoming vision signal, is applied by means of a commutator to each of these conductors when its end in the tube is situated in a bubble. The image is thus built up by a succession of gas discharges taking place within the tube in accordance with the strength of the received signal at any instant.

Patent No. 299076 relates to improvements in picture telegraphy, whereby a picture of any desired size can be transmitted by cutting the photograph into strips, which are then joined end to end, and scanned in two dimensions. Fig. 3 is a plan of the transmitter, in which the picture in the form of a "ribbon" is wound off a drum (12) on to a drum (10) through a guide (26) and exposed to illumination by two lamps (30) through an opening (28). Spirally arranged lenses (2) in the scanning disc (4) throw an image on to a light-sensitive cell (8). A clutch handle (36) enables the tape-feed shaft (18) to be meshed with the motor-driven shaft (22). At the receiving station the picture is recorded in strip form. The strip is then cut up into lengths, which may be marked off by the synchronising signals and re-arranged to form the picture.

Refinements in magnetically sustained tuning-forks are of interest in considering synchronising methods. Fig. 4 illustrates a recent *Patent No.* 297762 granted to J. A. Smale, where a tuning-fork (1) is normally controlled at constant frequency by means of a coil (2) energised by a battery (3) and an intermediate contact (5). Further adjustment and control is provided by two damping coils (27) and (30). The latter, which is in series with a variable resistance (31), gives an initial adjustment of the normal frequency.

The coil (27) enables a finer adjustment to be secured. A contact (9) is closed once every second by a guaranteed time device such as a chronometer (10) for a definite short interval, and is in series with a

Fig.4.



contact (6) closed at each vibration of the tuning-fork leg. When both contacts occur simultaneously at definite intervals, the resulting current through the coil (27) remains constant as this coil is inserted in the plate circuit of a valve (20) which is resistance-coupled to another valve (8). Should the contact (6) fall out of step with the chronometer contact (9) the effective duration of the impulse applied to the grid of the valve (8) is shortened. The resulting current-charge in the plate circuit of the valve (20) tends to maintain the frequency of the fork absolutely constant at a definite multiple of the speed of the chronometer.

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THE BEST LETTERS OF THE MONTH

The Editor does not hold himself responsible for the opinions of his correspondents. Correspondence should be addressed to the Editor, TELEVISION, *26, Charing Cross Road, W.C. 2, and must be accompanied by the writer's name and address.*

RIANT-MONT,
LA ROSIAZ,
LAUSANNE.
February 2nd, 1928.

THE EDITOR,
"TELEVISION."

DEAR SIR,

I must thank Mr. Wolfson for his very interesting letter, and I in return do acknowledge my false assumptions, and at the same time I take the opportunity of giving a few explanations and enlarging my previous idea if only to try and suggest other similar means to accomplish the end described in my last letter.

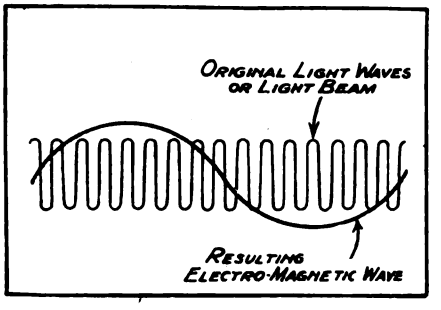
I agree that the frequency of one beam of monochromatic light cannot be altered by changing its velocity, as otherwise, as your correspondent rightly pointed out, the colour of the light would change according to the media of different refractive indices it passes through.

Nevertheless I still uphold that by means even of two identical monochromatic rays heterodyning can in a sense be effected by altering the velocity of one of them, or by altering the velocity of both by different amounts. The resulting ray may or may not be of a light frequency; but it will certainly be of a considerably lower one than that of the original monochromatic rays.

Imagine two glass parallelepipeds, each having a different refractive index, placed one on top of the other, and suppose that a perfect contact be made between two highly polished sides admitting no air between them. In practice this can be obtained by the fusion of two such glasses or by using a crystal having dissimilar refractive indices along two separate optical axes, or even a glue or gum which sticks to glass can be imagined.

Now into each of these two media direct two identical monochromatic rays, so that they meet under a very small angle at the two surfaces in contact. It is evident that owing to the two different speeds of the rays there will be moments when they are in phase and others when they are out of phase; in other words, a kind of stroboscopic action will take place. No one will deny that there will be a resulting ray; it will still, of course, be of electromagnetic nature, and presumably of a lower frequency; I cannot for myself conceive the opposite case. I shall now try and explain the reason for admitting a resulting ray of lower frequency, but would first mention that prior to the two rays entering the glass parallelepipeds it may be necessary, as is easily conceived, to polarise them.

Now it will be realised that when the rays are completely out of phase owing to the advance of half a wavelength of the one on the other they compensate each other and balance out. When they are in phase their effects are added and the maximum intensity is obtained. There will therefore result a final wave having a maximum of twice the intensity of, and a considerably lower frequency than, the original waves. As I said before, it may help your readers to compare this with a stroboscopic effect. The following is a diagram which may be of help:—



It is evident that I am not able to represent graphically the second monochromatic beam of the same frequency on account of the increased speed, but you can figure it in your mind, and I trust no reader will have any difficulty in seeing how the resultant wave is formed.

Let us examine this question from another point of view. According to Mr. H. Wolfson's letter, heterodyning can only take place with two wavelengths of different frequencies, but which may have identical speeds. In other words, two different wavelengths are required for this purpose, and I uphold that whether you change the frequency or speed heterodyning can take place. In other words, in order to be able to heterodyne two identical electromagnetic waves either the speed or the wavelength has to be altered; it *does not matter which*. Example:—

let λ be the wavelength of an electromagnetic wave;
v be the speed of propagation;
N be the frequency;
Then

$$\lambda = \frac{v}{N}$$

From this it is evident that by altering either v or N the wavelength must change; therefore, if you alter the speed of a light wave its wavelength must change. For heterodyning purposes your correspondent suggests that only the frequency N has to be changed while v may remain constant. By altering N heterodyning can therefore take place; but is this not also so by changing the speed (velocity) and keeping the frequency constant? In my opinion in this latter case heterodyning can and must also take place.

Now I entirely agree with your correspondent, but it seems to me odd that when the speed of monochromatic rays is altered by passing them through media of different refractive indices they do not change their colour owing to their different speeds. Yet is not every monochromatic colour characterised by its wavelength? Evidently there is a flaw somewhere! Will anyone of your readers offer an explanation or give the right one? Perhaps there really is a change in the wavelength, only no medium has a sufficiently pronounced refractive index to make the difference in the change of colour perceptible. If, as I presume, this difference is very small, we have here immediately an excellent means for heterodyning the rays, the right way to obtain a resultant wave of the order of a short wireless one. (May I add here that I should welcome an article in TELEVISION on Heterodyning in the widest sense of the word.)

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Perhaps, on the other hand, the colour of light depends only on the frequency, and one definite primary colour can have different wavelengths under varying circumstances according to the medium it travels through. But if the relation $\lambda = \frac{v}{N}$ is examined from another point of view one is led to assume the exact opposite. From the expression $N = \frac{v}{\lambda}$ it is readily visible that if the wavelength is kept constant and the speed altered the frequency must change. This immediately leads to the contrary statement that the colour of light depends on the wavelength and not on the frequency. Now in wireless does the power to heterodyne depend uniquely on the frequency, or could an intermediate frequency be obtained by using two identical frequencies at different speeds? I fear not, for I see no means of changing the speed in a wireless circuit. And here I must disagree with the analogy raised by your correspondent; "velocity" is not synonymous to "quantity of electricity" as the quantity (ampères) can vary with the velocity the same way as in a waterfall the quantity of water can vary from season to season, but the velocity of the falling water is always the same and is independent of the quantity and obeys certain laws of gravitation.

Concerning the first point raised by your correspondent Mr. Wolfson. My idea of using a copper plate was only because I could think of nothing better. I hoped to get constructive criticism from other readers, and to see their own ideas expounded on this point. Anyway, it *is* conceivable that, if by some means currents having definite positions are produced in a copper plate, and the effect of these currents amplified and induced into a corresponding plate (copper wire grid), the new currents will take up identical positions to the first ones.

I shall be much obliged for any help or criticism Mr. Wolfson or any other correspondent can give, and I shall await with interest further letters in future issues of TELEVISION.

Yours faithfully,

E. P. ADCOCK.

Through the courtesy of the Editor of the WIRELESS WORLD *we are able to reprint the following two letters :—*

THE EDITOR, "WIRELESS WORLD."

DEAR SIR,

Mr. Cosens has fulfilled a public service in so clearly setting out in your correspondence columns the facts concerning the possibilities of radio television. It must not be forgotten that the Baird Company has made most explicit claims concerning the successful performance of their apparatus right from the start of their enterprise, and now that the argument concerning the problems of picture analysis has bought into prominence a serious difficulty, vague suggestions are thrown out regarding "frequency modulation" and "strip analysis." I ask that all readers of radio experience should carefully read the article by J. Robinson in the current issue of TELEVISION. The arguments and suggestions contained therein reveal clearly that a new system of picture analysis and radio modulation is essential or, in other words, that without some such development television is a failure. If Dr. Robinson has invented a device which provides a means of overcoming what have appeared to be insurmountable difficulties I trust that he will see fit to convert it into practical form. If his proposals are associated with the construction of practical apparatus, it is to be hoped that he will do one of two things: Get on with the job, or, alternatively, make his work the subject of a paper to be read before the Institution of Electrical Engineers.

Prolonged argument as to the feasibility of radio television shows conclusively the existence of serious difficulties. One might contrast the claims made for television with the achievements in the field of picture telegraphy and the success of the Fultograph. From the onset the Fultograph people have given radio demonstrations on all occasions, while we still await an actual radio demonstration of television, however crude, before, say, those responsible writers in our radio journals who will undoubtedly hail television as a new enterprise possessing unbounded possibilities.

It was stated in the *Wireless World* that the demonstrations given at Olympia last September were conducted between wire-connected stations, thus eliminating the real problems of television—modulation and synchronisation. That the public as well as the radio journals have no prejudice is indicated by the recent activity in picture reception, about which there is no doubt concerning technical details in view of the considerable activity among manufacturers. A boom in picture reception seems to be evident. Radio enthusiasts have given no more initial attention to picture reception than to television, yet of these two new developments the one is unanimously endorsed while the other is with almost equal unanimity neglected. That the judgment of the technical experts of the B.B.C. should be in keeping with this point of view is only further evidence that the Baird system presents special problems when applied to radio transmission, though in view of the weight of general opinion the decision of the B.B.C. need scarcely be added in arriving at a clear judgment in the television situation of to-day. Our leading radio journals and societies have adopted a similar attitude, while it is significant to note that the council and supporters of the Television Society have not sprung from among the leaders of radio interests.

Instead of further debating the possibilities of practical television, let us bear in mind that a single successful demonstration would be convincing. Let us remember also that this controversy could never have arisen had the sceptics been answered with technical argument and had the comments and challenges been combated.

A. MOIR.

February 6th, 1929.

THE EDITOR, "WIRELESS WORLD."

DEAR SIR,

I should not have troubled you with this letter had it not been for the gratuitous discourtesy of your correspondent, Mr. A. Moir, to the President and Council of the Television Society, published in your issue of January 30th. Mr. Moir observes that "it is significant that the Council and supporters of the Television Society have not sprung from among the leaders of radio interests," as if the study of the science and art of applied physics was wholly embraced by writers on "radio interests."

Whilst Mr. Moir's letter contributes nothing whatever to our knowledge of the subject under discussion, it is noteworthy for his ignorance of the many wireless television demonstrations given before competent physicists, including the President, Dr. Fleming, Professor Cheshire, and over eighty members of the Television Society, with visitors, at the December meeting, who greeted a wireless demonstration on the commercial televisor with expressions of satisfaction and astonishment at the marked advance evidenced by the active and full-toned images received.

Also a deputation of Post Office engineers officially attended a demonstration of the Baird apparatus and unanimously reported the demonstration by wireless to be satisfactory and suitable for a test through a broadcasting station. Whilst Dr. Fleming, who I suppose Mr. Moir will recognise as a leader in radio interests, has written with reference to sceptics of Baird's wireless demonstrations: "That recognisable images of moving and living objects such as human faces have been transmitted even to large distances by wire and by wireless, by Mr. Baird's methods, admits of no manner of doubt. Those who deny it have simply not seen it. There are sufficient credible witnesses of it to place it quite beyond the region of dispute."

Yours faithfully,

CLARENCE TIERNEY,
Chairman of Council,
The Television Society.

INTEREST IN CHANNEL ISLES.

29, HAUTEVILLE,
GUERNSEY.
January 13th, 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

I feel compelled to enlighten your correspondent, John O. Le Lacheur, who believes that he is the only person in Guernsey interested in television. I am personally acquainted with several people in this island who are very interested in television, and feel sure that there are many others with whom I am not acquainted. Many of the above-mentioned people either possess sets now or intend to do so in the near future.

Yours faithfully,

A. R. YATES.

[Having recently visited the Channel Islands, we are in a position to confirm that there are many persons there who are very keenly interested in television.—ED.]

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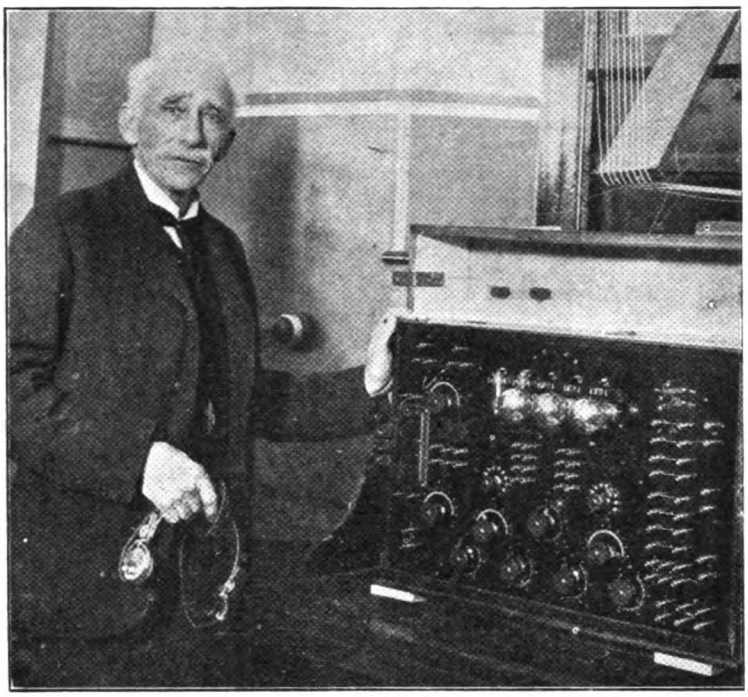
THE OFFICIAL TEST—AND AFTER

6D MONTHLY

Television

The Official Organ of the Television Society

VOL. 2 APRIL 1929 No. 14



SIR AMBROSE FLEMING, D.Sc., F.R.S.

President of the Television Society, and a frequent contributor to this magazine, whose recent recognition in the New Year Honours List has called forth the hearty congratulations of all his many friends and admirers.

On Page 53 of this issue there is an arresting article by Sir Ambrose, entitled "What is an Electron?".

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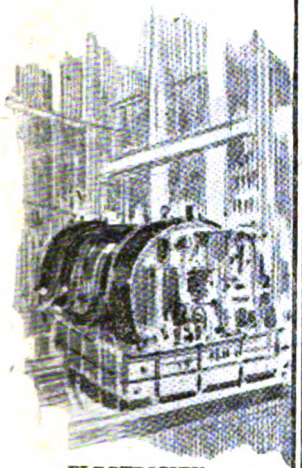

ELECTRICITY

MECHANICS

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CINEMATOGRAPHY

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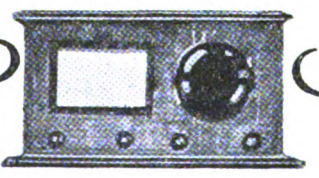

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THE WORLD'S FIRST TELEVISION JOURNAL

The Official Organ of The Television Society

Edited by A. DINSDALE, A.M.I.R.E.

Consultants: Dr. C. TIERNEY, D.Sc., F.R.M.S.; W. J. JARRARD, B.Sc. (1st Hons. Lond.), A.R.C.S., A.I.C

Technical Editor: J. C. RENNIE, B.Sc., A.M.I.E.E.

Vol. II] APRIL 1929 [No. 14

EDITORIAL

HEARTY CONGRATULATIONS.

SINCE we last addressed our readers on this page the New Year Honours List, the publication of which has been delayed this year owing to the serious illness of H.M. The King, has appeared. It is a particular source of gratification to us, and to all members of the Television Society, that our eminent contributor and their President, Professor J. A. Fleming, D.Sc., F.R.S., has been knighted.

* * *

OUR readers do not need reminding of the great work which Sir Ambrose has accomplished during the course of a long and active lifetime devoted to the science of electrical engineering. An associate and collaborator of Marconi's since the very early days of wireless telegraphy, Sir Ambrose is perhaps best known for his invention of the thermionic valve which has made possible wireless communication in its present forms.

* * *

IN addition to this outstanding invention he has also done a very great deal in connection with other branches of electrical engineering, with which his interests have been identified during the past half century. During the past year recognition and honours have been awarded him from several quarters. We have, in these pages, already had the pleasure of announcing the award to him of the Faraday Medal, one of the greatest honours in the electrical engineering world. Since then, Sir Ambrose has been given the Freedom of the City of Liverpool. And now comes the greatest honour of all, public recognition of his services to science by the King. We feel certain our readers will join us in extending to him hearty congratulations and best wishes for the future. On another page there is a most valuable article by Sir Ambrose which deals with a subject of fundamental importance.

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* * *

THE OFFICIAL TEST.

ANOTHER event of considerable importance which has occurred since last we appeared in print is the official test of the Baird system of television by the

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British Post Office. This test was conducted by wireless through the medium of B.B.C. stations, and is referred to elsewhere in this issue by other contributors. The Oxford Street and Marconi House transmitters were employed, one broadcasting the television signals and the other the accompanying speech signals. Televisors were installed at the G.P.O. and at Savoy Hill.

* * *

GREAT secrecy was maintained during the test, and neither the the Baird Company nor the Postmaster-General has issued any statement on the subject since. From statements which have been made in the newspapers and in the House of Commons, however, we gather that those present at the Post Office included the Postmaster-General, Mr. Baird, Sir Ambrose Fleming, and several M.P.'s. The demonstration, we understand, was in every way successful.

* * *

READERS are no doubt wondering what is the object of this test, and why there should be so much secrecy about it. They will remember, of course, that the B.B.C. representatives attended a demonstration some months ago, and reported that television was not then sufficiently perfected to warrant the commencement of a television broadcasting service.

* * *

THE object of the recent test was to enable the British Government (through the Postmaster-General, who is in charge of the Government department which in this country controls all forms of electrical communication) officially to examine the invention and determine whether it is of sufficient value and interest to warrant the institution of a public broadcasting service. The test was of a purely non-technical character; those present were asked to judge simply by results. Technical problems can be dealt with by others as and when the time comes to solve them.

* * *

UP to the time of going to press no announcement has been made as to the official opinion of the demonstration, but such indications as there are appear to be favourable. Before deciding to place the Government's hall-mark of approval on this British invention, the Law Officers of the Crown have many points to consider, but undoubtedly the invension merits that approval, and should receive it forthwith.

* * *

QUITE apart from the question of a television broadcasting service in this country, the support of a British invention by the British Government means a very great deal. It means, amongst other things, the greatly enhanced prestige of the invention in foreign countries. The British companies engaged in the work of developing the Baird system of television are very naturally interested in the disposal of foreign rights, and the official recognition of the system by the Government of this country is, in our opinion, long overdue.

* * *

THE result of immediate official recognition might well be that British interests would obtain a virtual monopoly of television throughout the world, thus adding to our national prestige and creating a new industry which will undoubtedly give employment to many thousands of people and provide a new source of revenue to the nation.

* * *

WE have a parallel case in wireless. When Marconi first came to England and successfully demonstrated his apparatus he received the full support of the British Government, with the result that this country saw the commercial birth of wireless communication, and for many years held a virtual world monopoly.

* * *

AS we have frequently pointed out, television is still another form of communication, and also the fastest known means of communication. Since the advent of the electric telegraph it has been the policy of the British Government to exert control in this country over all forms of electrical communication. Where this communication is carried on over a wire, those persons who are at the two ends of the wire are in an excellent position to exert control. With the advent of wireless communication the situation changed. Those in possession of a wireless transmitter can exert control over its use. But what they cannot do is to exert control over the ether, the medium through which their signals are transmitted. They cannot prevent their signals reaching a foreign country, and they cannot prevent them being picked up by anyone who possesses a suitable receiver.

* * *

THE Baird system of television is undoubtedly far in advance of any other known system in the world, and if those who are set in authority over us will only act on the Prince of Wales's recent remarks on salemanship, and tell the world that this *is* so, this British invention may yet give us a control over world communication in a way hitherto undreamed of, for it must not be forgotten that television can be used for transmitting, not only scenes, but also written and printed matter . . . **instantaneously** . . . **throughout the world.**

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What is an Electron?

By Sir AMBROSE FLEMING, D.Sc., F.R.S.

In the realm of science the hypothetical theories of yesterday become the accepted "facts" of to-day; and the accepted facts of to-day come, in their turn, to be upset or entirely reversed by the acceptance of the hypothetical theories of to-morrow. To-day the electron is accepted as being one of the fundamental facts, or foundation stones, of our world. We thought we understood the electron; but the recent work of Professor G. P. Thomson, which our distinguished contributor describes in the following highly illuminating article, casts serious doubt upon the very nature of this fundamental particle, as hitherto conceived by scientists.

ALL those who are interested in the action of the thermionic valve or of the photo-electric cell, so essential in television, know perfectly well that in the former appliance electrons, or small particles of negative electricity, are shot off from the hot filament; and that in the latter the impact of light waves upon the photo-electric material (say, potassium hydride or rubidium) causes a projection of electrons from that material.

Probably most people visualise the electron as a very tiny sphere with a negative charge.

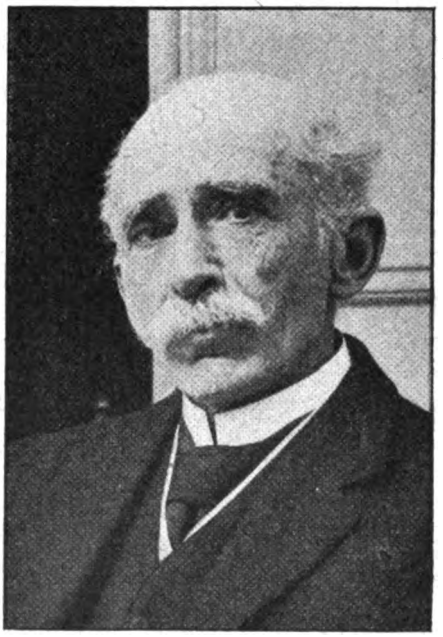
We are also accustomed now to think of a chemical atom as comprising a nucleus built up of electrons and protons, around which a family of electrons revolve like moons round a planet. Thus the hydrogen atom is assumed to consist of a single proton with a single electron revolving round it, or rather the two revolve round their common centre of mass.

Electron Characteristics.

These electrons and protons are small charges of electricity ($=4{\cdot}77\times10^{-10}$ electrostatic unit), and, physically speaking, may be considered to be centres from which lines of electrostatic force radiate. Where the electron moves uniformly it carries these lines with it; and the lateral or sideways motion of those electric lines creates magnetic lines of force at right angles to the electric lines and to the direction of motion.

It can be proved that when the speed of the electron is large—approaching that of light—the electrostatic lines crowd up into the equatorial plane of the sphere, and the lines of magnetic force are circles with centres on the line of motion and planes perpendicular to it. The electron as it flies carries with it its system of lines of electric and magnetic force. The energy of the electron is stored up in and represented by this electro-magnetic field, and the lines are by Maxwell's theory assumed to have inertia.

The electron in motion is equivalent to an electric current, and the inductance of the moving electron is only the inertia of its system of



Sir AMBROSE FLEMING, D.Sc., F.R.S.

lines of force. Hence, if an electron at rest makes a sudden jump forward or is accelerated, that means has its velocity changed either in magnitude or direction, the result is to produce a distortion or kink in each line of electric force which flies along it, just as we can produce a moving kink or hump on a stretched rope by giving one end of the rope a sudden jerk up and down.

As the transverse portion of the line of electric force moves along the rest of it, it creates a line of magnetic force at right angles to it, and to the line of motion. Hence we have produced an electro-magnetic pulse consisting of a shifting surface in which electric and magnetic forces exist at right angles to each other.

If the electron jumps backwards and forwards the pulse is repeated, and we have produced an electro-magnetic wave. This pulse or wave conveys energy. Hence an accelerated electron parts with its energy as an electro-magnetic wave.

This shows that an electron could not, under the above conditions, rotate round a proton permanently like the moon round the earth. The electron would radiate its energy owing to its acceleration, and the electron and proton would soon fall together and annihilate each other.

Hence some additional hypothesis is necessary if we are to assume the permanence of atoms in which electrons rotate round nuclei. This was supplied some years ago by Dr. Niels Bohr, a Danish physicist. He made, in fact, three assumptions which, however arbitrary they appear to be, have been justified by their consequences.

First, he postulated that an electron cannot revolve round an atomic nucleus in an orbit of *any* radius, but only in certain prescribed orbits called "permissible" or stationary orbits, in which, for some unknown reason, it does not radiate.

Secondly, the atom only radiates waves when a planetary electron jumps from one orbit to another.

The energy of the planetary electron is greater the larger its orbit. Hence, when the electron falls from an outer to an inner orbit, energy

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must be liberated, and this takes the form of radiation.

Bohr's Hypotheses.

Bohr's second hypothesis is that the frequency (n) of the radiation produced when an electron is jerked from an outer orbit where its energy is W_1, to an inner orbit where its energy is W_2, is given by the formula

$$n = \frac{W_1 - W_2}{h}$$

where h is a constant, called Planck's constant, equal to $6{\cdot}55 \times 10^{-27}$ erg seconds. This radiated energy is visible as a spectral line when examined by the spectroscope.

Thus, if we send an electric discharge through rarified hydrogen, impacts of electrons with atoms are created. The gas glows with a reddish light, and if we examine this light with a prism we find it consists of four bright lines in the red, blue, and violet part of the spectrum. These radiations are respectively due to electrons being caused to jump from the third, fourth and fifth orbit into the second orbit of various atoms.

It will thus be seen that the frequency of the emitted radiation or waves has nothing to do with any natural vibration frequency of the atom. The old-fashioned idea was that the atom was a sort of tuning fork which, when struck, vibrated at a certain rate. The modern idea is that the frequency of the radiation, and therefore its wavelength, is dependent solely on the initial and final energies of electrons which jump or are knocked from one permissible orbit to another.

Bohr's theory has been justified by the way in which it enables us to predict the wavelength of radiation emitted from certain atoms, but we have so far no explanation of the reasons for the peculiar assumptions on which it is based.

As long as we regard the electron as a small electrified particle with a certain mass, it is almost impossible to see why its jump from one orbit to an inner one should give rise to electro-magnetic waves which are of definite wavelength, and exhibit themselves as a spectral line either in the visible or invisible parts of the spectrum.

Certain very extraordinary facts have come to light lately which seem to indicate that the electron is itself a wave, or rather a collection of waves, and that it has, when in motion, a system of waves associated with it. Some of these we shall very briefly describe.

In the first place it must be explained that one fundamental characteristic of waves of any kind is their power to interfere or annihilate or strengthen each other. It is illustrated by the effects exhibited by a so-called diffraction grating. This consists of a plate of glass ruled by a diamond with very close parallel lines, about 20,000 to the inch. These scratches are opaque to light, but the glass between the scratches is transparent.

Let us then consider what happens when a beam of parallel monochromatic (or one-colour) light falls on the plate. Each little transparent strip is a window which sends out light in different directions. Let us suppose the width of the window and of the opaque scratch to be the same. Let the thick lines in Fig. 1 be the cross-section of the scratches, and the thin lines that of the windows. Consider a point P on a screen at a distance. Light will come to it from all parts of all the windows. If the wavelength of the light is such that the difference of the distances from P to a at the left of one window, and that of P to c at the left of the next window, then it will be clear that all the waves arriving at P from the windows ab and cd differ in phase either by one or more wavelengths. Hence they will augment each other, and the point P will be brightly illuminated.

If, however, the difference of the distances Pa and Pc is half a wavelength or an odd number of half wavelengths, then the light from the windows ab and cd respectively will destroy each other, because the crests of waves from every point in the window ab will arrive at P at the same instant that hollows of waves from corresponding points in the window cd arrive.

The same is true for every pair of adjacent windows.

Hence, if we look through such a grating at a slit illuminated by monochromatic light, we shall see a series of images of the slit on either side, getting gradually fainter as they are further off.

If, instead of being ruled with parallel lines, the glass plate was covered with minute spots of some opaque material with transparent parts between, it would be equivalent to a number of lines crossing each other in all directions.

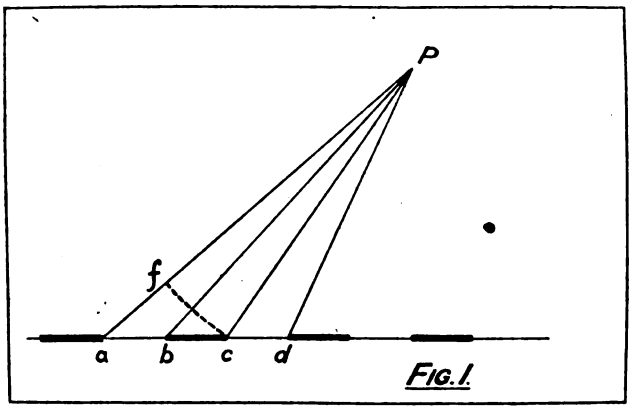

FIG. 1.

Diagram illustrating the principle of the diffraction grating.

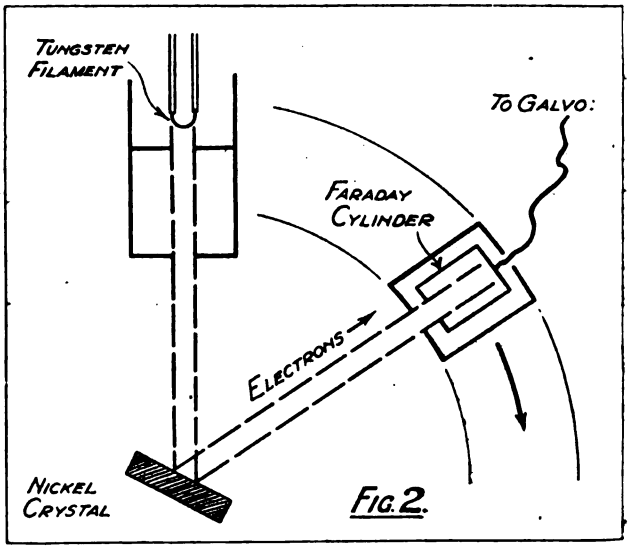

FIG. 2.

Apparatus for measuring the electron-stream reflected from any angle of a nickel crystal. The Faraday cylinder can be moved round radially so as to catch the electron beam at any angle. The whole apparatus is enclosed in a vessel which can be highly exhausted.

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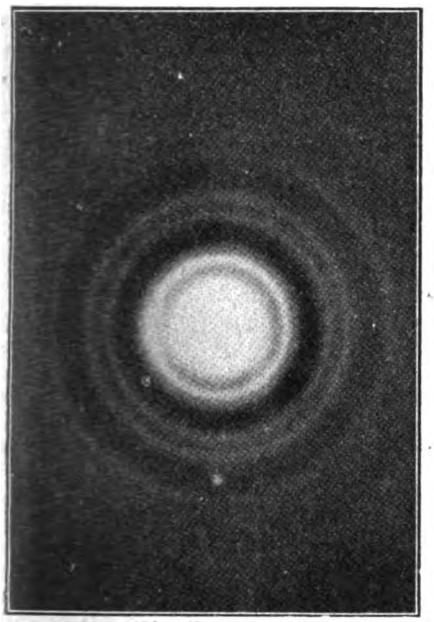
Suppose, then, we looked through such a dotted plate at a bright spot of monochromatic light, we should see that spot surrounded by a number of rings of light with dark spaces between. This is called a diffraction pattern or effect, and it is a direct



[Photo by courtesy of G. P. Thomson.

Fig. 4.
Diffraction images produced on a photographic plate by electrons which have passed through a thin film of gold, and been subjected to a strong magnetic field after passing through the film and before reaching the plate.

consequence of the fact that light is a wave phenomenon.

The halo seen round the moon when the air is full of particles of water is a diffraction effect.

Now it has been discovered that a stream of electrons can in the same way produce on a photographic plate rings or halos, which seem to imply that waves of some kind accompany a moving electron.

The most significant are the experiments of Professor G. P. Thomson, of the University of Aberdeen. He projects a stream of electrons, shot off from a cathode like bullets from a Maxim gun, against an extremely thin film of metal, say gold, platinum or aluminium.

On the other side of the film, at a distance of 8 to 12 inches, is a photographic plate. The film of metal is so thin (not more than a few atoms in the thickness) that it is quite transparent.

If, then, the electron were a mere particle of matter we should expect that the effect on the photographic plate of a thin stream or jet of such electrons would be at most to make a small blackening, when developed, of the plate. As a matter of fact, what Professor Thomson found was a series of concentric circles of light and darkness—in fact, a diffraction pattern. (See Fig. 4.)

This Fig. 4 is a reproduction of an actual photograph taken by Professor G. P. Thomson, and which he kindly sent to the writer. The production of this concentric ring pattern by the thin gold leaf proves that we have here to deal with a wave phenomenon.

The important and most interesting discovery of Professor G. P. Thomson, however, is that if a powerful magnetic field is created between the gold leaf plate and the photographic plate this not only changes the path of the electron and shifts the image on the plate, but also shifts the wave system as well.

This proves that the system of waves, whatever may be their nature, is not like the waves constituting light, but is in some way tied up to the electron so that wherever the electron goes, they go as well, or else the waves guide the electron.

This shows that in an electron we have not merely to deal with a material particle but with a system of waves which must co-exist with it before it passes through the gold or other metal film.

A very similar effect can be produced with X-rays and a crystal. When the nature of X-rays was under discussion, the happy idea occurred to Max von Laue, of Berlin, and to Sir William Bragg, and his son, Professor W. L. Bragg, that as the atoms in a crystal are regularly arranged they may act as a diffraction grating for X-rays, which are of much shorter wavelength than ordinary light.

It is essential that the grating spacing shall be of the same order of magnitude as the wavelength if diffraction effects are to be well seen.

Consider the case of a crystal, say, of rock-salt or sodic chloride. The atoms, or rather ions, are arranged in this case at the corners of a cube. Every positive sodium ion is surrounded by six negative chlorine ions, and every chlorine ion by six sodium. Their mutual attractions and repulsions maintain the ions in position, but they can vibrate about mean positions.

If, then, a slender beam of X-rays is sent through a crystal of sodic chloride, and a photographic plate placed beyond it, we find on it certain regularly arranged black dots which are due to the diffracted X-ray beams, and from the position of these spots the relative position of the atoms can be found. (See Fig. 5.)

If in place of a slice of crystal we were to employ a thin layer of ordinary powdered salt (sodic chloride), which consists of small crystals irregularly arranged, then the spots on the photographic plate would run together into more or less ill-defined rings.

The presence of the diffraction effect proves, however, that we have in the X-rays a wave phenomenon, and it can be shown that the average wavelength of "hard" or penetrating X-rays is more than a thousand times smaller than the average wavelength of visible light.

In place of a transparent or glass plate ruled with a diamond, and employed as a diffraction grating for

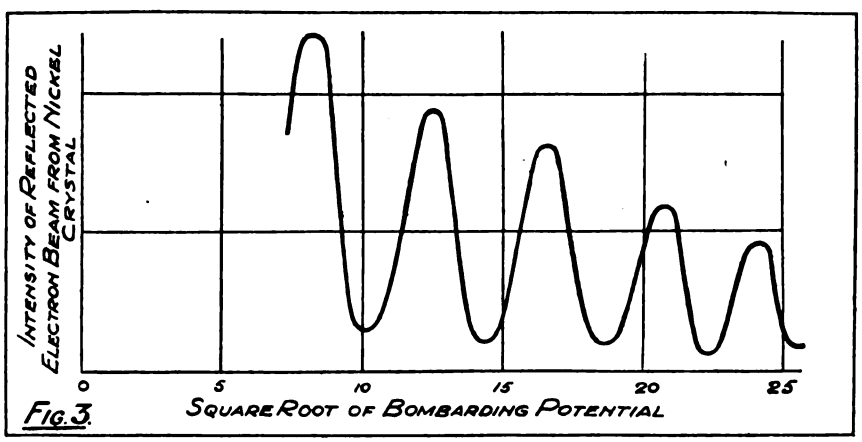


Fig. 3.

Rough reproduction of curve showing relation of intensity of regularly reflected electron beam to velocity of incident electrons. The curve shows a series of maximum values for regularly increasing velocities.

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transmitted light, we can rule close lines on a metal plate and obtain diffraction spectra by reflection.

In fact, this is the usual procedure, because there is a great advantage in using a curved surface for the grating. The metal is then ruled with a diamond with about 20,000 lines to the inch.

If rays of light from a slit are allowed to fall on this grating, not only is there a regularly reflected ray, according to the ordinary law, but also secondary rays due to diffraction on either side. If the light is monochromatic, these produce images of the slit of the same colour. If the light is white, then these secondary rays are expanded into spectra of the rainbow colours.

Remarkable to say, a very similar experiment has been conducted with a stream of electrons allowed to fall upon the surface of a nickel crystal. The different layers of regularly arranged nickel atoms then act like a diffraction grating.

These experiments have been carried out by Messrs. C. J. Davisson and L. H. Germer in the Bell Telephone Laboratories, U.S.A.

The apparatus used (see Fig. 2) comprised an incandescent tungsten filament from which electrons were projected in a stream against the crystal, and the regularly and diffracted beams collected by a Faraday cylinder connected to a galvanometer, so as to measure the electron current sent off at any angle (see Fig. 3) from the crystal.

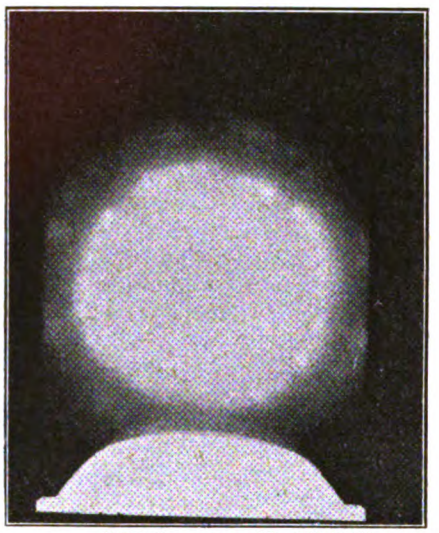
It was found that when a single crystal of nickel was employed as reflector, that there was a maximum reflected electron current in the direction corresponding to regular reflection. If the reflecting surface was an ordinary plate of nickel composed of a mixture of irregularly arranged crystals, then no such maximum was found.

This effect, viz., the regular reflection from the crystal surface. and the non-reflection from a polycrystalline surface, would be quite comprehensible if electrons were waves having a wavelength comparable with the distance between the atoms.

Another similarity is as follows: If the bombarding potential (that is, the speed of the incident electrons) is gradually increased, the intensity of the regularly reflected ray does not increase also regularly, but passes through successive maxima as shown in Fig. 3.

This is closely analogous to a diffraction effect found to exist with X-rays, in which the regularly reflected beam of X-rays increases in intensity by jumps as the wavelength is continuously altered. In other words, there is a reflection when the wavelength has certain exact values, and little or no reflection for intermediate values.

But this effect in the case of X-rays is dependent on the fact that the regularly arranged layers of atoms in a crystal act like a diffraction grating, and at any given angle the reflected rays from different layers



[Photo by courtesy of Prof. G. P. Thomson.

A photograph taken under similar circumstances as described under Fig. 4, but in this case the electron stream passed through a thin film of aluminium instead of gold.

combine to exalt each other when the atom distances have a certain relation to the wavelength expressed by the formula:

$$2d \cos \theta = n\lambda.$$

where d is the atomic distance θ the angle of incidence, λ the wavelength, and n an integer number.

The details of all these interesting experiments are given in a pamphlet issued by the Bell Telephone Research Laboratories in June, 1928 (Reprint B326), which is a record of a lecture by C. J. Davison, entitled "Are Electrons Waves?"; and also in a pamphlet issued in September, 1928, giving an account of experiments of Davisson and Germer on "Reflection and Refraction of Electrons by a Crystal of Nickel."

The result of these investigations is to show that an electron of mass m, moving with a velocity v, behaves in some cases as a wave of wavelength h/mv, where h is Planck's constant.

The fact remains that just as we cannot explain all the phenomena of light or of X-rays on the assumption that these agencies are waves and nothing else, so we cannot explain all the properties of electrons by the assumption that they are mass particles or simple charges of electricity and nothing else.

Certain phenomena of light and of X-rays are only explicable on the theory that these have a corpuscular structure—that is, are equivalent to particles shot out from the radiant source. Thus, for instance, a beam of X-rays does not ionise or break up every atom of a gas through which it passes, any more than every bullet fired in a battle hits a man. If, however, light were only waves, then every atom of the gas is equally exposed to their influence. A ray of light has evidently, therefore, a double character. It is partly corpuscular, and partly undulatory in nature.

In the same way an electron exhibits a double character. It acts partly as if it were a small mass of electrified matter, but partly as if it were a train of waves.

It seems clear there is some kind of pulsation taking place in connection with the electron which indeed may ultimately be found to be something of the nature of a stationary wave.

As long as we are dealing with matter in large masses the classical methods of dynamics are valid, but when we discuss the physics of the atom they do not suffice, and we have to substitute for them the ideas connected with wave mechanics.

It is clear that there is much to be learnt concerning the nature of an electron, and just as we have been able to resolve chemical atoms into structures built up of electrons and protons, so we may be able to resolve electrons and perhaps protons into structures built up of waves.

But then comes the question: *In what medium are the electrons waves?*

We can only conceive of a wave as an undulation in something. What is that something in the case of electrons?

There is no finality in physical research. Our goal of to-day is our starting point of to-morrow, and the present problem in physics is to find a more complete answer to the question:

What is an electron?

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An Amateur Looks In

My Impressions of the Big Test

By a Special Correspondent

I HAVE just experienced a red-letter day in my life, one which will live long in my memory and which in later years I shall be able to regard as a milestone in the progress of that most wonderful of all sciences—**television.** The satiation of my desire to become conversant with a subject which bids fair to alter the whole aspect of our everyday life has been brought a step nearer to fruition. Every new and epoch-making invention gives rise to destructive criticism, but invariably this scepticism is born from a sheer inability to probe the true facts of the case.

Television has come to stay and will occupy the highest of places amongst the amenities of mechanical and electrical civilisation. This fact was recently brought home to me quite forcibly, and is the reason for my putting pen to paper to describe what I both saw and heard.

How it Happened.

It happened in this way. I can congratulate myself on being "one of a privileged few," for I had the loan of a Baird televisor and I possess a wireless set with which I can receive the television broadcasts at such times as they are "on the air." Now then, readers, doesn't that make you green with envy? It has given me hours of sheer delight, and its performance has been astounding. By the time these lines appear in print it will be common knowledge that the B.B.C., through the medium of the London station, has given the Baird television system a "pukka" test, and judged on what I both saw and heard there is not a shadow of doubt in my mind as to the tremendous potentiality of the system.

What then may be expected when regular television broadcasts are taking place. I cannot do better than give an eye-witness account of all that occurred.

A Great Surprise.

No doubt many of you know the characteristic note which one hears on picking up the television signals via the loudspeaker. You have heard it on the many occasions that the Long Acre transmitter has been working? Of late, however, I had noticed that nothing could be heard, and of course seen, on their particular wavelengths, and I had begun to wonder what was taking place.

Imagine my surprise then when by chance I was "ether raking" on Saturday morning, February 23rd. On 2LO's wavelength I picked up the television note with tremendous pep behind it. Having seen reports of sundry rumours concerning a B.B.C. tryout, my astonishment was perhaps not so great as it might otherwise have been, but really this was fine, I thought to myself. In the twinkling of an eye I had switched on the televisor set, and lo and behold I saw the immortal dummy which I gather boasts of the name of "Stookie." His features, of course, were familiar but how wonderful he looked "on his new wavelength." It seemed as if his countenance was veritably beaming anew as the result of his Savoy Hill environment.

Dress Rehearsals.

But there, I know you are itching to learn details of what happened actually on the day of days, so suffice if I say concerning prior activities in the ether that I successfully picked up further rehearsal tests on Saturday morning, March 2nd; Sunday morning, March 3rd; while on Monday morning, March 4th, I found that speech was being broadcast at the same time as the picture, and late at night—11.30 p.m. until midnight—I was given the opportunity of receiving some of the most perfect television transmissions I have ever seen. It was this late night culmination and the press rumours that had been brought to my notice that made me come to the conclusion that something of great import was pending, so I decided to leave my sets tuned in and switched on for the next day and thus be in readiness for any tests that might be held.

I had not long to wait, for at 10.45 a.m. on Tuesday, March 5th, I heard the familiar picture note roaring through on the loudspeaker. I was aglow with excitement, my mind giving way to such thoughts as—Were the batteries likely to give out at the crucial moment? etc. But any initial fears I had were all dispelled as the morning wore on.

Words fail me at this juncture to give full expression to the excellence of the results that were achieved. Once the televisor disc had run up to full speed the happy face of Stookie greeted me, for I had previously left the television receiver tuned to London's normal wavelength, and the picture was wonderfully steady both then and throughout the test. Every detail of that dummy's features was clearly visible. Knowing that speech had previously been sent out on prior tests on a wavelength of just over 300 metres, I prepared to watch and hear all that was going on, and luckily I had two friends with me who can bear out the authenticity of my statements.

What Took Place.

The announcer soon displaced the dummy and with a face wreathed in smiles told *all* his listening audience and *the privileged few* of his seeing audience that this was the first television broadcast whereby it was possible to both see and hear the artistes at one and the same time. The exact order in which the various artistes appeared is of no great import. Indeed I could not now give that accurately, I was so absorbed

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in the wonder of this newest child of science, an infant which, however, showed promise of prodigious growth in the future.

The vocal efforts of one young lady were apparently being appreciated by the group of experts who, I imagined in my mind's eye, were seeing and hearing as I was doing, for the announcer kept repeating at five to ten minute intervals: "We will now ask Miss King to give you another selection from her repertoire." A Miss Lulu Stanley rendered some excellent solos, while the accompanist was not forgotten; she introduced her features over the air, so to speak.

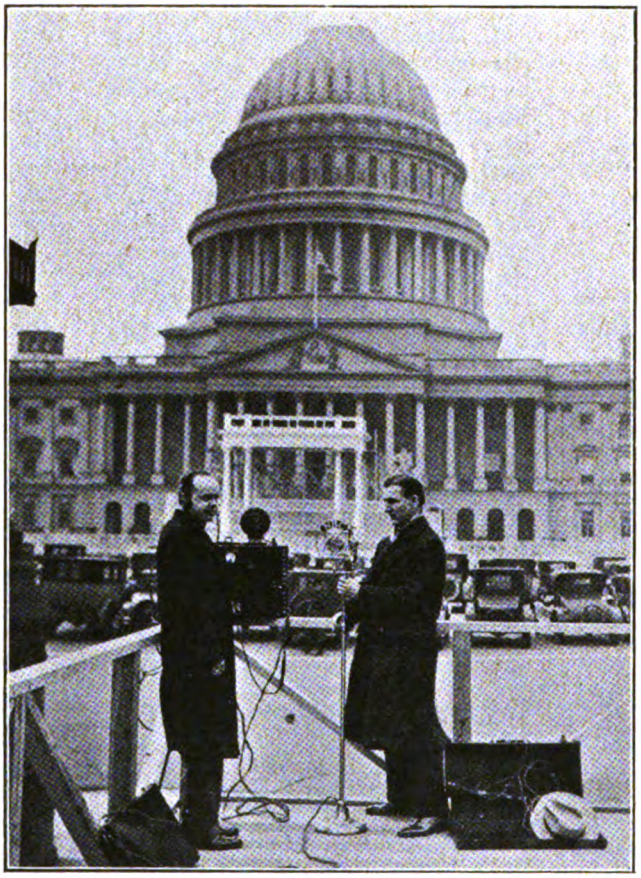
Mr. King, who was introduced by the announcer as the father of Miss King, proved a tiptop humorist, as also did Mr. Shaw, the points of their jokes being doubly impressive as the result of their facial expressions. So many comedian turns fall flat before the microphone through the absence of vision, but there was no risk of such an occurrence in this instance.

Familiar Faces.

That well-known actor, Jack Buchanan, made a television debut which, to recall his own words, was "to indicate his faith in the system." As one who has seen and applauded his real stage efforts, it was almost uncanny for me to see his familiar smiling face on the screen, but unfortunately his voice was both husky and weak as the result of a severe cold. Another much be-photographed man, the inimitable P. P. Eckersley of "Please don't do it" fame, faced the scanning disc and stated that he did not know how his features would come out, but he hoped his voice was all right. Let me assure him right away that he possesses a real television face. Every detail of his features, familiarised to the ordinary listener as the result of photographic reproductions, was clear cut and defined, and one felt it was the "Captain" himself who was actually talking in the televisor receiver and not someone many miles away. We say that wireless broadcasting has annihilated space, but how much more so is this true when it has television as an ally.

Printed Matter Shown.

In addition to the real artistes who appeared, the announcer held up photographic illustrations of His Majesty the King, the Prince of Wales, and the Duke of York.



[*Photo by courtesy of National Broadcasting Co., U.S.A.*

Engineers of the National Broadcasting Company (U.S.A.) arranging microphones in front of the Capitol in Washington, ready to broadcast to the world the inauguration ceremony when President Hoover took office recently. Four years from now, when the next inauguration ceremony takes place, we may reasonably hope, by means of television, to *see* as well as to hear the proceedings.

Even when these flat photographs were being televised — as distinct from the human being—the screen gave a faithful record, thus indicating the wonderful potentialities, let us say, as an example, to Scotland Yard. The photograph of a criminal could be televised for recognition purposes far quicker than it takes you to read these few lines. But there, let me get on with my story.

There was shown also the line drawing of a lady's head and the printed word "TELEVISION" was transmitted to show how clearly print would come out. On two occasions the announcer created a diversion by showing us his watch dial and saying: "The time is now so-and-so." Actually, he could have saved his breath, for the position of the watch hands was clearly visible on both occasions and the time could be noted with ease. I found myself instinctively looking at my own watch to compare times—and, of course, his was slow. Perhaps this was due to the time that elapsed between transmission and reception — the minutest fraction of a second!

The Concluding Item.

At about 11.50 a.m. the engineer in charge of the London station appeared on the screen and announced that "This morning's television test is now concluded and both B.B.C. stations, Oxford Street and Marconi House, are closing down." Just imagine the flutter in the flapper's dovecot at some future date when the particular announcer whose golden voice has charmed her ears for so long sends out his winning smile as well.

But there, one must not soliloquize, although under circumstances such as these it is excusable. This particular broadcast of television was on the air for just over an hour, but it was all too short. It whetted the appetite for more and more of a similar character, and let us hope with all our hearts that the realisation will not be delayed. Here is a chance for the old Mother Country to be first in the field by sponsoring the brilliant results of our countryman's pioneer work before other countries do so. The columns of this journal have chronicled the tremendous interest the Baird system has aroused in France, Germany, Holland, etc., so let it not be said on this occasion "that a prophet hath no honour in his own country."

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MIHÁLY'S TELE-CINEMA

By DR. ALFRED GRADENWITZ

In our issues for October, November, and December last we published the latest available details concerning television developments on the continent. In the following article our contributor gives us the latest information concerning the work of Mihály, the Hungarian inventor.

DÉNES v. MIHÁLY, a young Hungarain electrical engineer of undoubted technical skill and scientific genius, claims as far back as July 7th, 1919, to have transmitted pictures to a distance in such a way as to make them immediately visible. Reproductions at that early date, of course, lacked definition of outline, and, moreover, entailed the use of rather complicated transmitting and receiving apparatus. Nor were the first accounts of this achievement, which, of course, was still far removed from actual television, received without considerable scepticism, which did not give way before, in 1922, Mihály's book on "Electrical Television and the Telehor" was published in the German language.

The appearance of this book stimulated other inventors in the same field to renewed attempts in the same direction, the more so as the advent of radio broadcasting about that time opened up new uses for a successful television scheme. At the same time, however, economic conditions in Hungary compelled Mihály, at least momentarily, to give up his work and turn to other pursuits, until in the summer of last year, having resumed his early experiments, he brought out a new and simplified system able to transmit and receive lantern-slides and shadowgraphs.

Early Apparatus.

Mihály's original "telehor" was based on the use of highly sensitive oscillographs—i.e., electrical instruments comprising minute oscillating mirrors, for scanning the original picture at the transmitting end and rebuilding a reproduction of it at the receiving end. The rotating disc, as used by Baird, he regarded as a crude makeshift able at most to achieve some rudimentary television, but utterly incapable of even moderately delicate results.

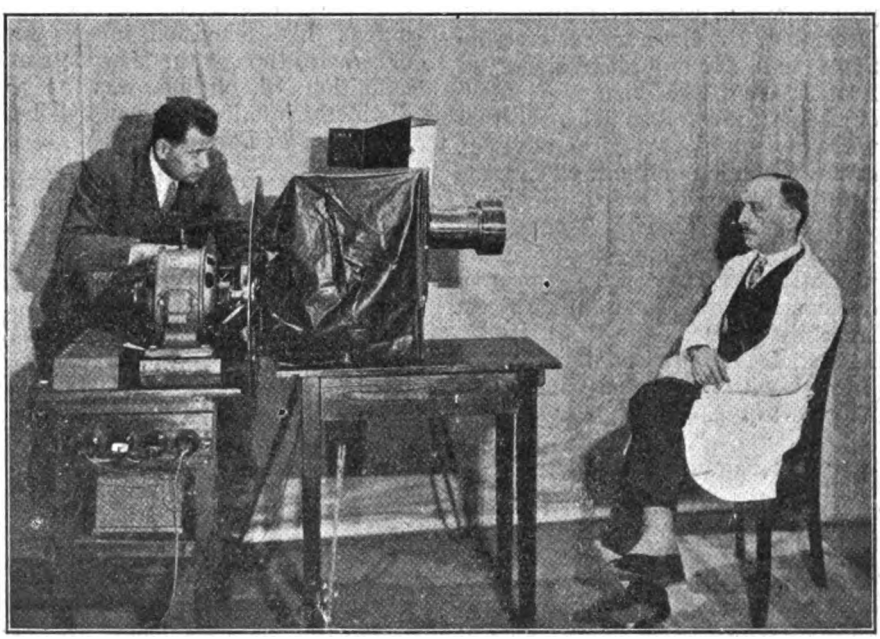
However, realising the drawbacks of his oscillograph, which did not seem likely in the near future to give even partly satisfactory results, he resorted last year to the once-despised rotating disc which, he said, though obviously inferior to his own telehor principle, might at least prove useful in demonstrating the practicability of his system. As, however, his work was progressing towards a satisfactory reproduction of lantern-slides, silhouettes, etc., he came to appreciate the possibilities of the disc, and now seems to have made up his mind definitely to cling to it, the more so as the production of cheap apparatus was, from the outset, his foremost endeavour.

Berlin Radio Exhibition.

This is how, in September last, at the Berlin Radio Exhibition, he was able with a remarkably inexpensive type of receiving apparatus to show results in no way inferior—nay, even slightly superior—to those which his German rival, Professor Karolus, of Leipzig University, working in conjunction with the Telefunken people, had been achieving with a much more elaborate and costly outfit. Though only including the reproduction of lantern-slides, demonstrations at that exhibition were with mild exaggeration termed television, and gathered round Mihály's stand crowds of interested visitors.

Personally, I must confess that my interest in these results suffered a severe set-back when, in November last, I was given a few demonstrations of Baird television in London. In another article* I have given a

* December 1928 issue. See also Dr. Frank Warschauer's impressions of the Karolus, Mihály, an Baird systems, published in our November 1928 issue.



Mihály's transmitting apparatus.

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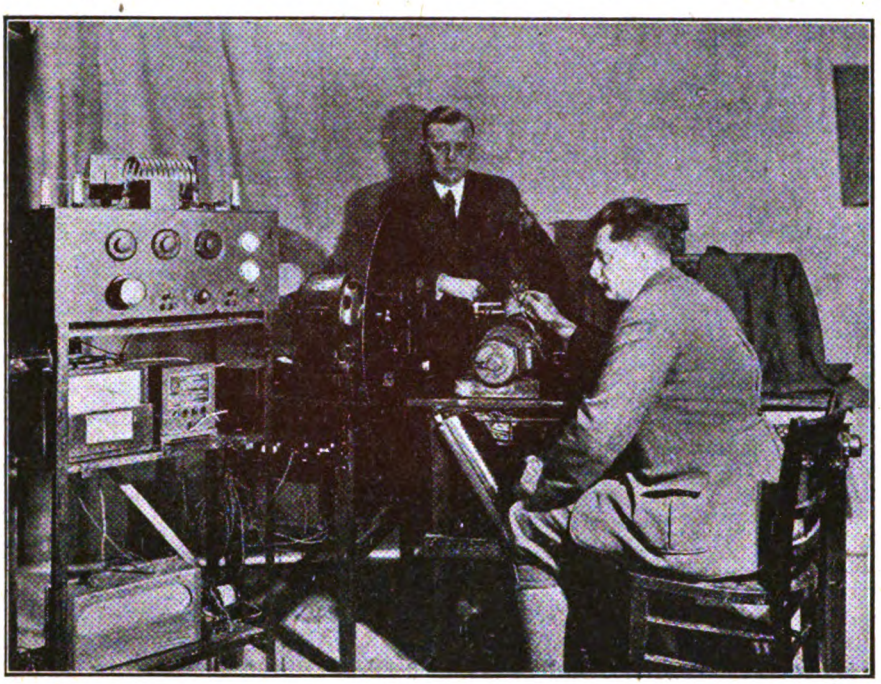
candid statement of the well-nigh overwhelming impression received during these first demonstrations, and I have tried to give readers an idea of the enormous difference existing between the transmission of lantern-slides and actual television —i.e., the immediately visible reproduction of people and their doings.



Mihály (behind) photographed with his tele-cinema transmitter.

London Demonstrations.

By a fortunate chance I was also present when, about the middle of December, Dr. Bredow, Secretary of State and High Commissioner of Broadcasting, the highest German official in the wireless field, together with two of his technical advisers, came to London and was given some demonstrations of Baird television. This semi-official visit resulted in the Baird Company receiving an invitation to come to Berlin and demonstrate television from broadcast transmitters there, the three experts having been very favourably impressed with what they had been allowed to see.

Renewed Activity.

I had heard nothing from Mihály and the progress of his work till, a few weeks ago, I was called up on the telephone and asked by the Hungarian inventor to come to his new laboratory and attend a demonstration. Being always anxious to see experiments in the television field, I gladly accepted, and, forthwith, betook myself to the laboratory, where I met Mihály himself and one of his assistants, Mr. Faragó. After a few introductory words the inventor left the room, and shortly afterwards a television image of a human face appeared on the screen of a receiver. The face was visible with only moderate flicker and a fair amount of detail, moving to and fro, smoking a cigarette and behaving to some extent like television images seen elsewhere, though the sharpness and definition of outline was as yet distinctly inferior to what had been shown me in London.

While thus examining the picture I was asked by the inventor's assistant if I recognised the man, to which I replied that, though he seemed familiar, I was not able to make out just who he was. "Why, this is Mihály himself!" Mr. Faragó exclaimed, and I had to apologise for my lack of perspicacity, drawing attention to certain shadows in the picture which seemed to stand in the way of recognition.

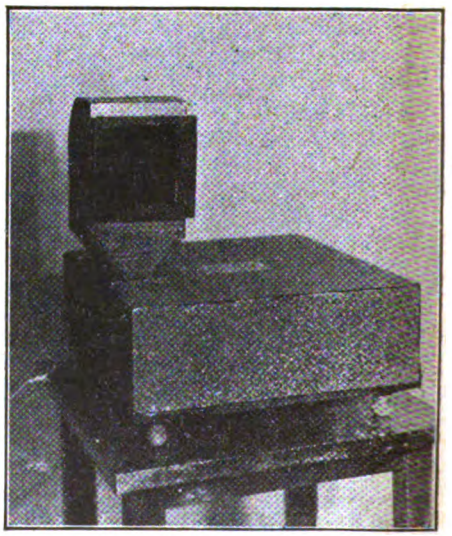
Cheap Apparatus.

When Mihály, a few moments afterwards, returned to the room I had to congratulate him upon his recent progress and his demonstration, which, seeing the crude apparatus intentionally used by the inventor, was quite satisfactory. During the discussion then following Mihály strongly advocated the use of cheap apparatus, claiming that, with larger and better receivers, in connection with an expensive and elaborate transmitter, he would be able to do as well as any other inventor in the same field. But, so he said, limitations of the available wave-band would prevent any but the crudest images containing a minimum number of elements (say 900), from being transmitted. Nor, he said, would any other inventor for this same reason be in a position to show anything better. He then went on to discuss the chances of the tele-cinema, which he had been engaged in developing, and when I asked him to give me a demonstration of this he replied that I could have one in the course of a day or two.

A few days elapsed and nothing was heard from Mihály, when suddenly the German daily press began publishing a large number of articles, partly illustrated, about the Hungarian inventor's new television cinema. Representatives of the press had obviously, in the meantime, been invited to witness demonstrations, and now commented rather favourably upon Mihály's recent achievement.

Tele-Cinema.

Though the word "television" had possibly not been mentioned in



Mihály's small tele-cinema and television receiver.

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connection with the demonstration just given me, I had used it myself, and the inventor, who had obviously seen that I took it for granted that it was television, had done nothing to contradict my belief. Again, a few days after the press demonstrations, when I asked Mihály to give me a private demonstration of the tele-cinema, I was told that, as his engineers were away, I would have to wait a short time. Still, seeing that practically the whole of newspaper comment turned about the tele-cinema, actual television being only referred to in passing, I could not help thinking that, after all, the demonstration was not, as I first had reason to think, actual television, but tele-cinema, in which case I should, of course, have to state that even the broadcasting of cinema films on the Mihály system is still at an initial stage. Others who have had a better chance to investigate the Mihály system told me that he had to show at the present moment mainly the tele-cinema, that as a matter of fact he had done actual television, but that this was yet of a very crude description, though the light used at the transmitting end in scanning the person to be televised—viz., powerful Jupiter lamps—was rather unpleasant both by its blinding effects and the enormous heat developed.

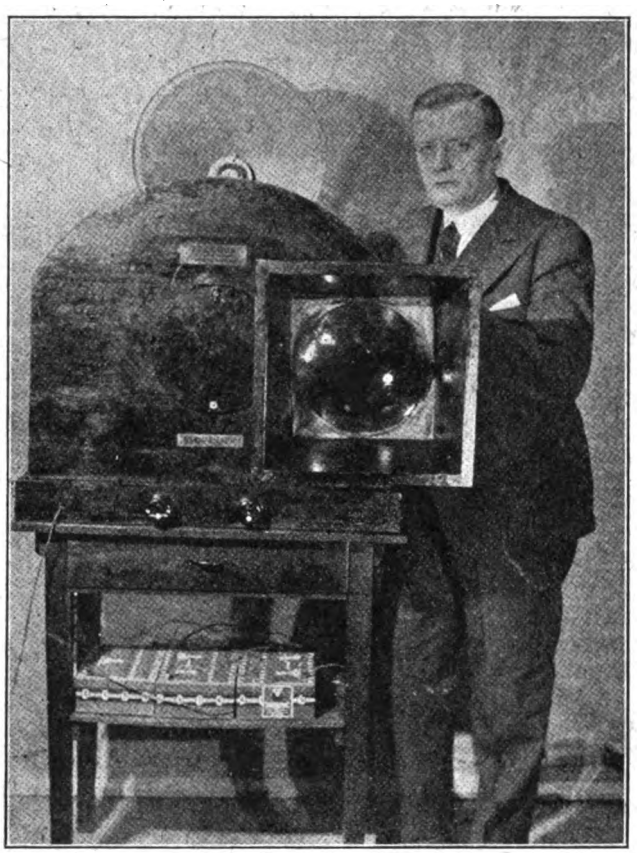
The Difference.

The main difference between actual television and the tele-cinema, of course, is that while in connection with the former, the various parts of the persons televised have to be scanned by *reflected* light, the case in connection with the tele-cinema is the same as with transmission of lantern-slides—viz., that only *transmitted* light is used. This, of course, entails an enormous simplification of the television transmitter.

Another difference is that the cinema film already comprises a decomposition of the original movement into successive stages, each separate picture corresponding to a different stage. In fact, all that is required is to scan the whole length of the film once at a certain minimum rate—i.e., ten individual images per second.

The Picture Element Question.

Mihály, like other inventors in the same field, has in the course of his work come to the conclusion that the effect of television images cannot be gauged by mere reference to a still picture consisting of the same number of elements. In fact, television images made up of even a very small number of elements will produce much better effects than a still picture similarly composed. This is why Mihály's 900-element pictures show much more detail than one would be inclined to suppose from so coarse a texture.



Mihály's large receiver.

In order, now, to decompose a given individual film picture into 900 elements—i.e., thirty rows each of thirty dots, a rotating disc is provided which near its circumference, comprises thirty small openings spirally arranged at distances apart which each correspond to the distance between two consecutive rows.

If this disc be set rotating at a rate of ten revolutions per second the beams from a constant source of light behind the disc will once during one-tenth of a second pass over the whole of one individual film picture, scanning its various shadings.

Greater Detail.

According to a recent improvement, some sort of diaphragm (stop) is provided which in succession covers up the upper and lower halves of the original picture, thus enabling the half actually bared to be scanned—with a correspondingly greater wealth of detail. The mutual distance of successive disc holes then is only one-half of what is otherwise required. While the size of each perforation in turn is reduced by half, the disc will rotate at a speed twice as high. This is how a greater fineness, or the subdivision of the picture into the double number of rows, is obtained, each of which in turn comprises twice as many picture dots.

Mihály, like other inventors in the same field, has, of course, long given up the use of selenium cells as light-sensitive devices, using photo-electric cells instead, which are not only more sensitive, but entirely free from any lag or inertia, responding instantaneously to any variation of luminous intensity by a corresponding variation of electric current. The special photo-electric cell used by Mihály has an alkali metal cathode facing a grid-shaped platinum anode, both of which are enclosed in a tube filled with some rare gas such as argon. The mode of action of this cell, according to tests by Hertz and Hallwachs, is due to the cathode on the impact of light, giving out a flow of electrons. The intensity of the electron stream is directly proportional to the intensity of the light falling on the sensitive surface. The current intensity in the dark is practically nil.

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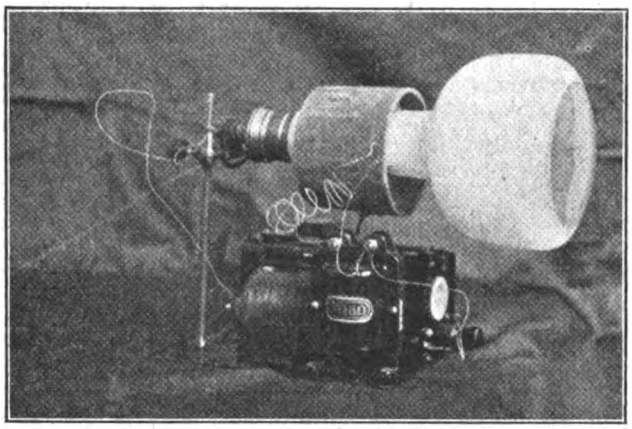
How the Picture is Scanned.

Now, the light beams allowed to pass through the holes of the rotating disc will, in accordance with the above, scan in succession the various points of the original picture—in the present case the cinema film picture. Passing through the film, they are reduced in intensity the more as the point of the picture actually struck is darker; bright spots will be traversed without any appreciable reduction. The sequence of current impulses corresponding to the various points of the original picture can, of course, like microphone currents, be transmitted either across a line of conductors or by wireless (by modulation of the waves sent out from a broadcast transmitting station), in order at the receiving end to be received by an ordinary radio receiver.



The Super Frequency Lamp referred to in this article. This lamp is used in the receiver instead of the more familiar (to our readers) neon lamp.

What there remains to be done at the receiving post to reconvert these variable current intensities—by a reversal of the process above described—into variable light intensities, and to reconstitute out of these a semblance of the original picture.

A New Lamp.

To this effect Mihály uses a peculiar source of light—a tungsten lamp which with its incandescent electrodes works without any lag, lighting the more strongly as the current intensity actually feeding it is higher. When traversed by a slight current impulse it will give out no appreciable light, while in the case of a strong current it will shine with a bright, intense light.

Now, as the current impulses arriving at the receiving end correspond to the alternately bright and dark elements of the original film picture, this lamp—termed super frequency lamp—is bound to burn brightly whenever there is some bright spot of the original picture being scanned at the transmitting station, and *vice versa*. Its beams, however, are allowed to pass through the series of holes of a rotating perforated disc similar to that of the transmitting station, and thus to reconstitute the original film picture.

Persistence of Vision.

Each individual cinema picture—i.e. each phase of the moving scene represented on the film, is scanned within a maximum period of time of one-tenth of a second, and, during the same interval of time, recomposed at the receiving end into a reproduction of this picture. Our eye, of course, has sufficient inertia to perceive these successive light spots of variable intensity simultaneously—beside and above one another—and, accordingly, to receive the impression of a continuous picture.

The tungsten lamp has recently been improved so as to give out a brightness two to four times higher than the one demonstrated at the Berlin Radio Exhibition. By means of a lens about 25 cm. diameter it gives fairly clear images that can be viewed from two to five metres distance. Ten pictures per second is, of course, a minimum, and it is thought that by speeding up the apparatus to, say, sixteen pictures as in accordance with the usual cinema practice, the flicker still remaining could be disposed of.

At the time of writing it is being rumoured that Mihály is already engaged in installing his transmitters at the various Berlin wireless transmitting stations. His first demonstrations, which I understand are to be limited to tele-cinema shows, are therefore likely to coincide with the Berlin demonstrations of the Baird Company, and to afford to Germans an unique opportunity of comparing the respective merits of the two systems.

A Simple Error.

(The leader of the little German band raised his baton and counted: "*Ein, zwei, drei.*")

British Fan, excitedly: "Crikey! I've got America."

'Arriet: "Got America, on that one-valver? Garn!"

British Fan: "Not 'arf I 'aven't! The blooming announcer just said DRY—and that's America."

—*Radio News.*

An audience "looking-in" at the large receiver, behind the lens of which a photograph would appear to have been placed for the purpose of the taking of this picture.

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Sydney A. Moseley

ON

THE TEST— AND THE RESULT

READERS will want to know, of course, all about the big test, what really occurred, and what the results portend.

As it happens (or should I have written "needless to say"?) I can supply the requirements of my readers—*from the inside!*

I was the only journalist privileged to be present at the Savoy Hill test, and since no other scribe was permitted to witness the results from the Post Office, this account may be taken to be exclusive, authentic, and historic! And so . . .

Strange to say, although one had a week or so to arrange transmitters, receivers, lines, and so on, it all seemed somewhat of a rush. Engineers of the B.B.C. were both friendly and helpful, yet with the best will in the world it was not found possible to put out television by wireless experimentally inside broadcasting hours. The test itself was actually timed to begin at 10.45, but a trial run was not possible before that time, because the 2 L.O. transmitter did not come into action before the official time. When the test proper began, the room was full of critics, all of whom saw the preliminaries of sighting in, etc.

Yet without these understandable difficulties, the need of perfect arrangements both at Savoy Hill and at the G.P.O. *under new conditions*, the results were entirely satisfactory.

Not a hitch anywhere. There were two receivers at each appointed place—a large combined radio-televisor such as one saw at Olympia during the Wireless Exhibition, and the small popular portable televisor which may be fitted to valve wireless sets. I have to admit that, although I have seen dozens of demonstrations by the larger televisor, I had never before seen what the small set could do. Judge my surprise and pleasure when I noted that the images in the smaller set *were even more clearly defined than in the larger set.* Dr. Montague Rendall, a Governor of the B.B.C., Sir John Reith, Director-General, Mr. Gladstone Murray, Sub-Controller, and Lord Angus Kennedy (Vice-President of the Television Society), all appeared to be keenly interested in this smaller set, which had the price £12 12*s.* marked on it!

In ordinary circumstances, the larger set should have been the better, but—these little things *will* happen—a condensor or some other gadget let the engineers down at the last moment.

As it happens, I am told that the results were in the reverse direction at the G.P.O. There the larger set more than justified, while the image on the smaller set was not so steady.

Thus one can see that—as in the case of ordinary wireless receivers—it depends on the set.

What was clear to friend and critic alike was that television is here. Each artiste and singer came over with unmistakable clearness. I was surprised and not in the least displeased to see Capt. Eckersley present, and I could hardly fail to let the opportunity pass without a little leg-pulling, which he took in good part. And I even went so far as to take him to the transmitting room and get him to televise, while his brother, Roger Eckersley, head of the Programmes Department, who waited below, declared that he recognised him instantly. In fact it was apparent to all reasonably minded lookers-in who were present that Mr. Baird had justified his claims.

What, then, could hold back experimental transmissions through broadcasting stations?

It is quite apparent that so far as the main purpose of the test is concerned it was an unqualified success. Do not lose sight of the fact that this was a non-technical test given for the purpose of ascertaining whether the ordinary man was sufficiently interested in Mr. Baird's invention. So far as I am concerned, I would state unequivocally that all who witnessed the transmission at Savoy Hill were completely interested, *including our friend Capt. Eckersley.*

It came down to this, then. Television in its present stage was sufficiently *interesting to broadcast.* It had definitely reached a practical

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stage. Came the question: *Could it be broadcast without upsetting the present broadcasting arrangements?* Were the technical handicaps insuperable, if indeed such handicaps existed at all?

Before dealing with this point I would say here that all I have been striving for up to the present has been to obtain an acknowledgment that television had reached this amazingly advanced state, where figures could be clearly seen and recognised, and where the personality of speakers or singers came over with fascinating clarity. My complaint all along has been that critics who were not aware of this advancement, or who had so far committed themselves in the past, that they *would* not budge from their position, had totally misrepresented television.

As I put it to Capt. Eckersley and his colleagues, the very minimum of justice would have been for the B.B.C. to have admitted, if they were not prepared to applaud, the coming of television. They, in all fairness, could have said: "Yes, here is television—a great achievement. But what about the technical problems?" Had this been done in the first place, the impression widely held that British television had not had a fair chance might have been obviated. And even now, when the air appears to be clearing, I am not satisfied that justice can be met without a full enquiry into the whole circumstances.

When you look back and review the intense campaign that has been waged by so-called British patriots on behalf of foreign inventors, and when you realise the lengths to which some of these critics went, it leaves me vastly disturbed. There is something rotten in the state of Denmark when public enterprise can be held up at the whim of individuals or at the behest of interested financiers.

However, this first part of the campaign is definitely over. Practically every prominent critic now agrees that television is here, and now it is up to the technicians to come to some accommodation in regard to the transmissions. Here, again, I plead for a sympathetic tackling of the problem by the B.B.C. engineers.

As I write, the attitude of the Post Office and the B.B.C. has not been officially made known, but in a conversation with the experts I am sufficiently emboldened to prophesy that the steps towards progress will be maintained and accelerated. In a word, our purpose has been achieved. Having established to the world the full claims to which Mr. Baird has all along been entitled, we will now proceed to show that the fears in regard to the technical side of the problem have either been exaggerated or, in fact, unfounded.

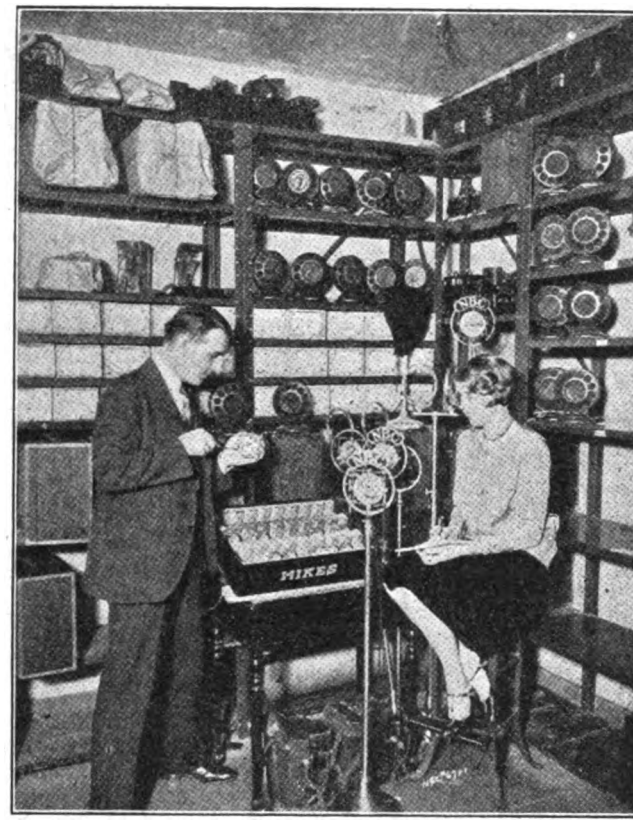
Those who imagined that I was unduly optimistic in proclaiming the advent of the broadcasting of television will soon be placed in a better position to judge.

Finally, without unduly beating the national drum, I would like to say how satisfactory it is to those of us who have been in the thick of the fight to know that, after all, the British lead in this great scientific achievement is to be maintained, and that Great Britain may after all be the first country to herald in the era of practical television.

The next move is a happy one. My friends at Savoy Hill have already met Capt. Hutchinson, Mr. Baird, and myself at lunch. We are exploring the best possibilities of putting television over, and the atmosphere, as I write, is one of extreme cordiality. My only fear is in regard to a certain group who are still persistent in an endeavour to forward the interest of a foreign rival for their own ends. If necessary the whole circumstances of this deplorable intrigue will have to be made public. I am only hoping it will not be necessary, and that the first steps towards broadcasting through the B.B.C., which will begin shortly, will result in the complete triumph of a British invention.

I repeat that I have written this article before the official decision has been made known, but unless I read the indication wrongly there should be a complete rapprochement between the B.B.C. and Baird as a direct result of the Post Office test. In my further conversations with Captain Eckersley we have explored in the friendliest possible manner some interesting means of getting television to the people. He openly and frankly admitted that Mr. Baird had reached a point of development which he had not thought possible, and that he was quite anxious to help him.

His problem appeared to be not whether television was here or whether it was sufficiently interesting, but was most generous in his reference to the new science, and I left him with the impression that he was going to do his utmost in fitting in experimental transmissions at the earliest possible moment. That, of course, is all to the good.



[*Photo by courtesy of National Broadcasting Co., U.S.A.*

A National Broadcasting Company engineer testing microphones in preparation for the world-wide broadcast of President Hoover's inauguration at Washington on March 4th.

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PANCHROMATISM

By H. WOLFSON.

A few moments' reflection will convince our readers that, in order to portray on a televisor screen a true-to-life image of a distant scene, it is necessary that the photo-electric cell employed at the transmitter shall respond more or less equally to light of different colours. That is to say, the cell must be *panchromatic*. This characteristic is still more important, and, indeed, vital, in the case of colour television. In the following article the writer draws upon the knowledge which colour photography enthusiasts have acquired in their search for a panchromatic plate, and suggests the lines along which the design of photo-electric cells (for television purposes) should develop.

THE subject of colour television has many points in common with the problems of colour photography, and it is essential that all those who are interested in the development of colour television should be well acquainted with the underlying principles of that vast subject, panchromatism, before attempting to design suitable light-sensitive devices.

From the viewpoint of television, panchromatic photo-electric devices are as yet unknown, and it remains for those of us who are sufficiently interested to do all we can to further research along the lines which I shall indicate in the course of my article.

The sensation of colour, which is produced upon the human eye, is some form of stimulus which affects the sensitive inner surface of the eye. This action is still not fully understood, and it is interesting to note that one of the more recent theories of colour vision is the so-called "Photo-electric theory of Vision."

Imperfections of the Eye.

It must be realised at the outset, however, that wonderful as the human eye undoubtedly is, it is at the best an imperfect recorder of colour. This is not difficult to understand either, when it is realised that the conceptions of colour vary with each individual eye, as is so well known in the case of colour blindness. Many of us, too, know how some people can detect slight differences in the shade of two almost identically coloured pieces of the same material, while others would agree that two quite dissimilar shades (to one eye) were "perfectly matched."

As is generally known, I think, white light is composed of seven colours, into which it can be quite easily resolved by the aid of a prism. These colours, taken in the order in which they appear in the spectrum, are red, orange, yellow, green, blue, indigo, and violet. Outside this band which can be perceived by the human eye, that is, outside the visible spectrum as it is termed, there exist other ether vibrations, of which the most important are the ultra-violet and the infra-red. Mention might also be made of the X-rays, which are in reality high frequency vibrations, whose wavelength is very much shorter than that of the ultra-violet light, though for the purposes of the present article we shall not concern ourselves with this latter part of the spectrum.

Both the visible spectrum, and those portions which we have termed the ultra-violet and the infra-red, are capable of producing chemical changes in the photo-halides, silver chloride and bromide. Since the natural recorder of vision is incapable of reproducing exactly either the hues or the relative brightnesses of the spectrum, it is not surprising that a more serious defect is present in photographic plates as ordinarily manufactured, by simply coating them with a sensitive emulsion of silver bromide or chloride in gelatine.

The colour of an object depends on the fraction of the light which it reflects, thus a red pillar box is coated with a pigment which absorbs all the colours of the spectrum with the exception of red, which it readily reflects. If, however, we were to examine our pillar box in a green light, which is devoid of any red component, we should be forced to conclude that the G.P.O. had painted all their boxes *black*, since a body which reflects no light is said to be black.

The Spectrum.

Figure 1 gives a rough idea of the spectrum with which we are particularly concerned, together with the wavelength of the various components. I am assuming here that everyone is familiar with the idea that light consists of waves or vibrations in the ether, of the same type as those employed in radio, with the exception that the wavelength is vastly different, for while we employ in radio, wavelengths varying between several thousands of metres and two or three metres, those which we meet with in connection with light are but a few hundred *millionths of a millimetre.*

The eye cannot appreciate slight changes in wavelength, of the order of 5 $\mu\mu$, and it has been suggested by Sir Wm. Abney that we possess three fundamental sensations of colour: a red sensation, one green,

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and the other blue. It would lead us too far from our present goal if I were to discuss this further, but it is interesting to note that the three colour sensation theory of colour vision has paved the way for the various three colour processes of colour photography.

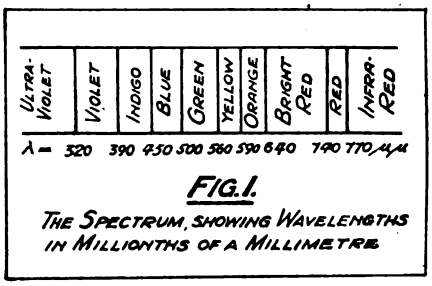

FIG. 1.

THE SPECTRUM, SHOWING WAVELENGTHS IN MILLIONTHS OF A MILLIMETRE.

Let us now consider the problems which have had to be overcome by various workers in the fascinating field of colour photography. It would, of course, be quite impossible to use the narrow bands of the spectrum corresponding to the three primary colours, but it was shown as early as 1867, by Ducos du Hauron, that it is possible to employ comparatively wide bands, each corresponding to about one-third of the spectrum, and by mixing these, to obtain an almost perfect imitation of natural colours. This idea has been developed by Baird in connection with colour television.

Colour Photography Operations.

For the production of a colour photograph, it is necessary to photograph the object three times, through different coloured filters. These are the red, green, and blue of the three colour sensation theory. Each filter has a definite duty to fulfil, in allowing to pass only light of the wavelength not transmitted by the other two. It will be seen then, that altogether, if the filters are properly designed so that there is a minimum overlap between the various colours, we shall obtain on our photographic plates the whole of the spectrum. The range of the colour filters is approximately as follows :—

Blue filter transmits 410 μμ to 500 μμ
Green „ „ 480 μμ to 590 μμ
Red „ „ 580 μμ to 770 μμ

Note the slight overlap of the three bands. (Fig. 2.)

The methods which can be employed for the production of colour photographs from these negatives need not trouble us, for though these processes are very important from a photographic point of view they lead us too far from our subject. Suffice, then, to say that the three negatives are made up as transparencies, and either stained with dyes corresponding to the colours of the original taking filters, or projected from separate lanterns so as to be superimposed on a screen. The three lanterns project in the three filter colours.

An Analogy.

We see the close analogy between Baird's colour television and colour cinematography, in which films are taken and projected under special conditions, employing colour filters.

We now come to the real difficulties which have been encountered in research on colour photography, and which are being encountered, in a similar manner, with colour television.

The ordinary photographic plate is sensitive, as we have already seen, to but a small region of the spectrum. It reproduces blues and violets as if they were white, while the reds, yellows and greens come out more or less dark or black.

We must employ plates which are equally sensitive to blue, green and red alike, and must turn then to the panchromatic plate, which satisfies our requirements excellently. This was developed from the so-called orthochromatic plate, which was discovered by Major-General Waterhouse. This latter type of plate is obtained by bathing the ordinary plate in the pink dye erythrosine, which confers upon the plate an extraordinary sensitiveness in the yellow-green region. Though large numbers of these plates are still manufactured, they are by no means panchromatic, for they are practically insensitive to red light.

Value of Dyes.

There are a large number of other dyes which confer upon a photographic plate a sensitiveness in a particular narrow band of the spectrum, but it was not until the discovery by German chemists of the isocyanine and cyanine groups of dyestuffs that any real progress could be made in the manufacture of real panchromatic plates.

The Great War put this country into a very difficult position, for prior to that time all these dyes had been imported from Germany, where they were manufactured by special secret processes. Great credit is, therefore, due to Sir Wm. J. Pope and his collaborators, who succeeded in producing these dyes in this country, and enabling both those already known, and several new ones in addition, to be manufactured in this country.

Owing to the enormous increase in light-sensitive properties which the plates acquire, after they have been bathed in these dyes, it becomes imperative that all bathing, drying and packing should be done in almost complete darkness. This will give the reader some idea of the effect, and it will be readily grasped that if we could discover some similar means of increasing the colour-sensitiveness of our present photo-electric and other light-sensitive devices, we should overcome one of the most important and difficult problems which confront us in our endeavours to attain colour television.

Dyes to Employ.

It will be convenient, then, if we pause a moment to consider the nature of these dyes. Sensitol violet is one which is largely recommended for panchromatic sensitisation, while this can be combined with a pre-treatment with some dye of the nature of erythrosine. Among other dyes which may be used to sensitise to red are the following: pinacyanol, dicyanine, sensitol red.

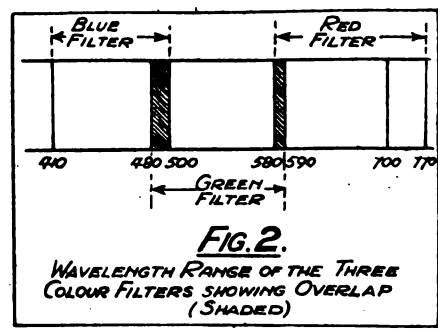

FIG. 2.

WAVELENGTH RANGE OF THE THREE COLOUR FILTERS SHOWING OVERLAP (SHADED)

For the yellow-green and orange, such dyes as isocol, orthochrome, pinaverdol, pinachrome and sensitol green may be used. Acridine orange, pinaflavol are used in place of erythrosine as orthochromatic sensitisers.

It is especially interesting to note the use of the dye dicyanine. This is a most expensive dye, costing in the neighbourhood of 90s. per gramme, though it is possible to

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obtain smaller quantities, say 5s. worth. A little of this dye goes a long way, and if any of my readers are using it they will find it advisable to make up a stock solution of a minute amount in alcohol. This can then be diluted as and when required. It must always be kept in the dark, when not in use, as it deteriorates when exposed to light.

Detecting the Human "Aura."

This dye has been used in research along rather novel lines, in the investigation of the human "aura." This is a a scientific reality, of which few people seem to be aware, which surrounds the human body. This is normally invisible, and though certain people, the so-called clairvoyants, may have the power of seeing the aura with the naked eye, it is an undoubted fact that *any* eye can perceive the aura, after it has been sensitised with dicyanine. This sensitisation is brought about by simply looking at a source of daylight through a cell containing the dye in solution, for a period of some five minutes and then looking at the patient in a semi-darkened room. The aura appears as a sort of mist or veil around the body.

My point in mentioning this is to draw attention to the apparent similarity between the sensitisation of photographic plates to the extreme red and infra-red, and the apparent sensitisation of the human eye. So far as I am aware, this point of view has not been previously advanced, but is, I think, quite likely.

For those who are interested in the production of panchromatic photo-sensitive devices, I would suggest research along similar lines, and those of my readers who read my earlier articles dealing with liquid photo-sensitive cells containing dyestuffs will realise the enormous possibilities.

A few words might be said here, in conclusion, about the colour-sensitiveness of ordinary photo-electric cells. This is best illustrated by means of a graph showing the sensitiveness of cells of the alkali metal type, containing lithium, sodium, potassium, rubidium and cæsium respectively (Fig. 3). We see from this that the maximum sensitiveness of a lithium cell is about 400 μμ, which is in the violet region of the spectrum. This cell then will respond admirably to light impulses of the particular wavelength denoted by $\lambda_{max.}$ but will have little or no response to light in the yellow part of the spectrum. Further, it will not give any response whatsoever to red light.

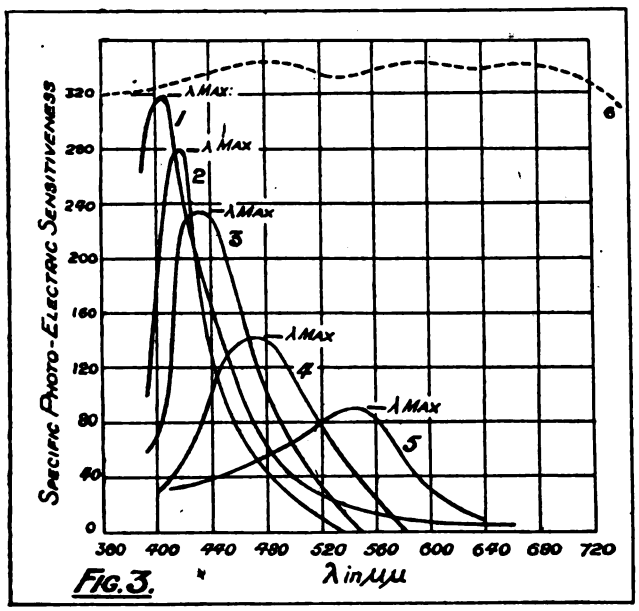

FIG. 3.

Colour sensitiveness of alkali metal cells: (1) Lithium. (2) Sodium. (3) Potassium. (4) Rubidium. (5) Cæsium. (6) Colour sensitiveness of panchromatic plate which may be taken as ideal for photo-electric cell.

Colour Sensitiveness and Atomic Weight.

A similar argument may be applied to the other curves, and we see that $\lambda_{max.}$ shifts gradually to the red region as the atomic weight of the alkali metal under consideration increases.

This might imply that it might be possible to so combine the alkali metals as to obtain a cell in which the colour-sensitiveness approached much more nearly to the ideal case of a panchromatic photo-electric cell. This is illustrated in Fig. 3 by the dotted curve, which may be taken as representing an almost panchromatic cell. It should be pointed out that such a cell does not as yet exist, but will undoubtedly be discovered in course of time.

Much research has been carried out in the determination of the colour-sensitiveness of various types of cells, and special mention might be made of the work of Shinomiya and of Seiler.

Summary of Results.

Their results can be summarised as follows:—

(1) The formation of an alkali metal hydride, as in the colloidal modifications of the ordinary cells, shifts $\lambda_{max.}$ to longer wavelength for all the alkali metals.

(2) Increase in atomic volume from lithium to cæsium shifts $\lambda_{max.}$ to the longer wavelength region.

(3) As the atomic weight of the photo-electric substance increases, the colour sensitiveness curves broaden out.

(4) With the employment of quartz containers, in place of glass, $\lambda_{max.}$ shifts to the region of longer wavelength.

(5) Filling the cell with neon in place of argon has a similar effect.

A Possibility.

Result (3) is to my mind of particular importance, for it should be possible, by choosing photo-sensitive materials of high atomic or high molecular weights, to so broaden out the curve as to approximate to panchromatism with a single cell, or else to achieve the desired result by spreading out the curve to cover half the spectrum, and finding a second cell to cover the remainder. This latter idea is not nearly so satisfactory, however. In Baird colour television the result was achieved by the use of a number of cells, connected together, each looking after a particular band of the spectrum. This is, of course, obviously unsatisfactory, and a very large field of investigation is therefore open for those who feel inclined to tackle the problem. I shall probably have more to say on the subject in later articles.

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Television—"Positively Marvellous"

By ROBERT WILLIAMS

Mr. Williams is one of the most interesting figures in Trade Unionism. He was the General Secretary of the Transport Workers' Federation, 1912–1925; Chairman of the International Transport Workers' Federation, 1920–1925; Labour Party Executive, 1918–1926; Chairman of the Margate Conference of the Labour Party, 1926.

MANY readers of TELEVISION will remember D. W. Griffith's great film entitled "The Birth of a Nation." It is true that I was not in at the birth of the epoch-making invention called television, but I was a privileged witness of a demonstration which proved, beyond a doubt, that television is in a very robust infancy.

In my negotiations with employers, numerous complaints have been made to me that the members whom I represented resented the introduction of labour-saving contrivances and devices likely to dispense with a certain volume of labour. Needless to say, I fought strenuously and steadfastly against any interference with mechanical contrivances and devices calculated to make labour easier, more facile, and more productive. The days of the Luddites who sought to break the machines are as remote, if not in time, at least in utility, as the flint-chipping of the Stone Age.

The manufacturers of commercial gas cannot stem the tide of demand in favour of electricity for lighting and power purposes, nor can the coal barons hold up motor transport and its employment of oil by means of the internal combustion engine. The Chief of Police of the municipal borough of which I was a member, in pressing for the extension of electric light, used to tell us that one arc lamp burning during the night was as effective in the prevention of crime as two police officers on patrol.

I can well remember the earlier bioscope in its initial stages, ever flickering and tiring the eyes. Modern film production has improved so vastly and rapidly that one fails to realise that one is the evolutionary product of the other.

So with broadcasting. When the head-phones and the first loud-speaker were coming into use, I dogmatically stated I preferred the worst gramophone record to the best loud-speaker, but in a year or so, and in consequence of enormous improvement, I changed my mind and got a three-valve set and an excellent loud-speaker.

I am confident that in the near future television will make equal and even greater headway than the gramophone, the film, the motor or the aeroplane.

Television is destined to have a greater effect upon the progressive development of human institutions than anything else of which I can think. It is useless for the B.B.C. and the Postmaster-General to range themselves against television. In so doing they merely make themselves ridiculous. Sir William Mitchell Thomson has political responsibility, just as Captain Eckersley has technical and administrative ability, but it is for the people, through their elected representatives in Parliament, to overcome the implicit, or avowed, objections of the technical and political representatives of the B.B.C. and the Post Office. If it is good enough for Germany and France to set up experimental stations for transmission purposes, if it is good enough for the U.S.A., where they have established some measure of freedom of the ether, then we in this country may justly claim similar rights and privileges.

Having interested myself on several occasions in listening-in and observing the products of the transmitters at Long Acre, I have taken several political friends to the demonstration centre.

I observe from press reports that at last televisors have been installed for experimental purposes at Savoy Hill and the G.P.O., and that the results conveyed over the ether to these points were all that could be desired. I myself, with my friends, have sat down before the transmitting instrument and have observed the facial movements and listened to statements made in another room, and have been authoritatively informed that just as they could convey facial movements, speeches, and songs from one room to another in the same building, so by the use of powerful transmitting instruments they could convey similar results across the Atlantic Ocean.

I understand Mr. Lloyd George, who is by no means backward in envisaging the possibilities of electioneering progress, has promised to attend a demonstration. Mr. MacDonald has been, and I am sure Mr. Stanley Baldwin will require no great amount of persuasion to do as other political chiefs have already done. It has been computed that not more than 20 per cent. of the electorate ever attend political meetings and, therefore, if the electorate will not attend public meetings in order to see and hear politicians, the politicians must arrange to be seen and heard in the homes of the large masses of our people.

Television should have a tremendous effect in maintaining peace between the nations of the world, and just as we are spending large sums of money on preparedness for war, we should be able to provide for the introduction of all means and methods to prevent the outbreak of war. It is being urged, with how much justification I do not know, that vested interests are standing in the way of the establishment of an experimental station, either under public or private auspices, in order to let the people themselves judge of the potentialities of television. If this be true, these vested interests must be brushed aside. Of this I am satisfied, that Parliamentarians of all parties will overcome, if there is sufficient public pressure in support, any and every vestige of vested interest or official obscurantism which stands in the way of this most marvellous piece of inventiveness becoming as popular as the film, the "talkie," or ordinary broadcasting.

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HIGH TENSION CURRENT SUPPLY

The Mains Unit compared with other Methods

By W. C. FOX

In our January and February issues Mr. Fox gave details of methods of charging low-tension accumulators at home without bother. He will now proceed to discuss ways and means of doing away with expensive and inefficient high-tension batteries. Constructional details will be given of an H.T. mains unit having a high-current output suitable for television experimenters.

THE arrival of the thermionic valve in the wireless world was very like the arrival of Pandora's Box. It brought many new troubles with it and only a ray of hope in the shape of more sensitive detection and a power to amplify. Not the least of the troubles it released was a demand for high-tension current. In the early days small pocket flash lamp batteries were quite good enough, but as valves improved their current demands increased, with the result that small H.T. batteries gave way to triple capacity cells, then to accumulators, and now the only method of meeting the ever-increasing demand is by some form of mains unit.

At present makers and the public alike seem to be timidly nibbling at the idea of drawing high-tension current from the electric light mains, and, as in nearly every other branch of wireless, the new idea has been greeted in anything but a friendly manner. The best mains unit at present obtainable does not provide more than 200 volts at a trifling milliamperage—a current supply which is quite inadequate for the operation of any reasonably powerful wireless set, and introduces far too many difficulties if one is to conduct any television experiments.

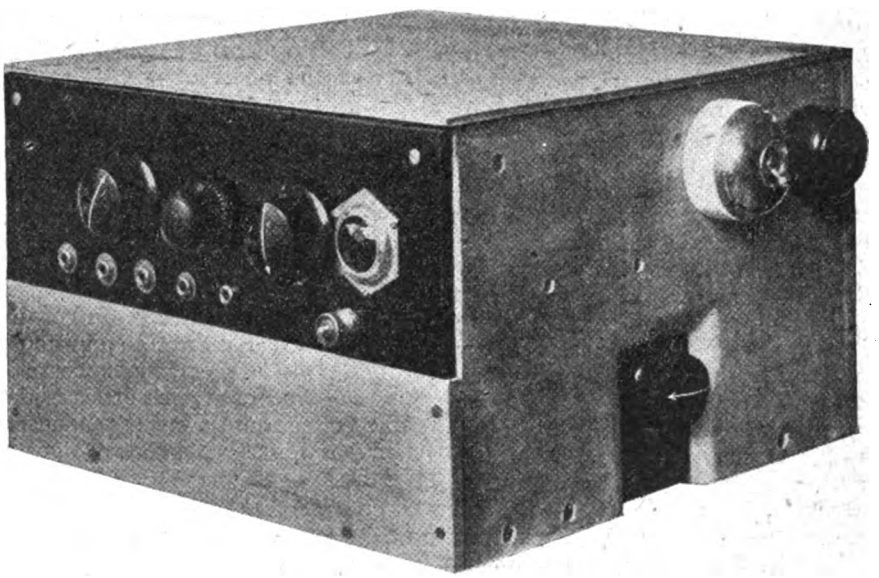
Much has been written, too, about the danger of mains units and the risks of fire and fatal shocks and so forth. In the first place a mains unit is no more dangerous than an electric iron or kettle (it does not take half as much current), and there is no more need to have special fuses and precautions in the case of the one than the other. As far as current output is concerned a mains unit, when worked off alternating current, will only give off a definite wattage. If, for the sake of argument, the wattage rating is 20, at 500 volts one can only get 40 milliamperes and any attempt to increase the milliamps. will result in a fall in the voltage to such a figure as will make the multiplication of volts by amps. come to 20.

Accumulators v. Mains.

In the case of high-tension batteries or accumulators this does not apply. If for any reason they are shorted or put on an unusually heavy load they continue to deliver their full voltage, or a very large proportion of it, and quite a considerable amperage as well. A high-tension battery, when shorted, will deliver enough amps. to fuse flex wire while an ordinary 10-amp. hour accumulator on a dead short will for a second or so turn out over 100 amps.!

Looked at from this point of view a mains unit giving quite a high voltage is a far safer article to be experimenting with than either batteries or accumulators giving equivalent voltages. This fact has been mentioned and the rather startling figure of 100 amps. given (which is quite correct and if anything an under-statement of the figure rather than an exaggeration of it) because in some quarters a point has been made of the "danger" of using high voltage mains units. Incidentally a magneto on a car or motor-cycle gives very high voltages indeed.

The only real "danger" that exists is to the filaments of the valves, for within its limits the mains unit operates with all the remorseless firmness of the 1,000 h.p. generator behind it at the power station, and if one miscalculates and has a voltage dropping resistance of too low a value and so gets too many volts on a valve the emission will disappear in a most surprising fashion.



View of complete eliminator, constructional details of which will be given in next month's "Television."

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Otherwise a mains unit properly designed, built, and adjusted is a most satisfactory source of high-tension current, for one can always be sure the volts are there. With any sort of batteries there is always a doubt.

The mains unit herein described has an output of 40 milliamperes at

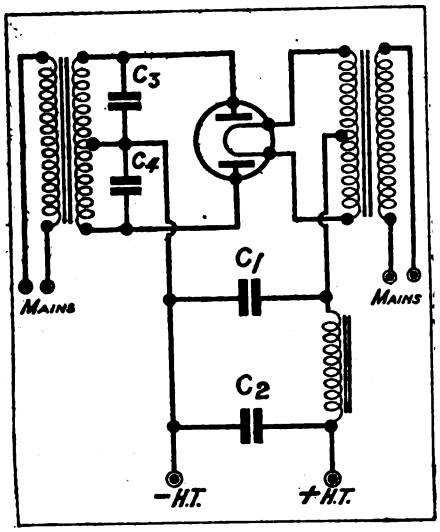

Fig. 1.
Theoretical diagram of mains unit for alternating current with centre tapped transformer.

300 volts, which is more than sufficient to operate a four-valve set with an L.S.5 valve in the last stage. It is not by any means a large unit, but its general arrangement forms a useful basis on which to work.

The first golden rule to observe in connection with mains units is to have one supplying rather more current than is actually required, for any attempt to work it beyond its rated capacity leads to trouble. Voltage drop from this cause has already been mentioned, mains hum will become pronounced, and "motor boating" in one form or another also may set in.

It will be noticed from the theoretical circuit diagram that two transformers are used—one to supply the plate current and the other for filament current.

The reasons for this were briefly: Two transformers are not so likely to get individually as hot as one combined instrument; each can be more heavily constructed and better insulated than a combined instrument, and, finally, if at any time a valve requiring a different current rate has to be used it is far cheaper and easier to replace the filament transformer than a combined instrument.

From the theoretical diagram it will be seen that each transformer secondary has a centre tapping, that of the filament supply becoming the positive lead while that from the plate becomes the negative lead.

In the case of the filament transformer the centre tapping is not essential. The electrical centre of the winding can be picked up by a 400-ohm potentiometer placed across the output, the arm becoming the centre tapping. In some cases this may be found effective in completely eliminating mains hum and can quite easily be tried, even if there is a centre tapping. One merely covers the end of the wire with insulating tape or covers the terminal (whichever form of making contact with the centre of the winding is provided) to prevent accidental contacts to it, and then proceeds as though there were no centre contact.

When using a potentiometer the arm will normally be placed about the centre of the resistance element and then adjustments made one way or the other until the most silent position is found. It is not a critical adjustment.

Of the condensers used in the circuit those at $C1$, $C3$, and $C4$ in the theoretical circuit will have to stand the highest voltages and should be mica condensers tested to 500 volts a.c. or over, according to the secondary voltage of the plate current transformer.

All condensers that come after the choke coil or coils can quite well be paper condensers of the ordinary Mansbridge type tested to 500 volts direct current if the final voltages are of the order of 300 or so. In the instrument described these condensers are a mixed lot, there being a Dubilier, a T.C.C., a Hydra, and a cheap foreign condenser of unknown make. Although during building up and testing the mains were several times switched on to the set without there being any load on the output side, or the load was taken off first and the mains left on, a condition of things which either way is theoretically believed to give rise to considerable voltage surges in the condensers, none of them have shown signs of failure.

As regards the condensers shown at $C3$ and $C4$ it may be thought at first glance that as the current is alternating these would "short" to a certain extent each half of the winding across which they are placed. Such is not the case, however. They are quite small and serve to soften off the very sharp peaks of the current which has been transformed up to a higher voltage than that of the mains. In this respect, too, they form the first step in the smoothing circuit and have a definite effect in eliminating mains hum from the final output.

The disposition of the choke or chokes in the filter circuit depends very largely on the requirements of the circuits with which the unit is to be used. In a general way a choke of about 50 henries and ample current carrying capacity is sufficient, but if a particularly smooth supply for, say, a detector valve in a wireless circuit is required it is better to have two chokes, that supplying the detector valve and H.F. valves, if there are any, having an inductance of 100 henries while the choke supplying subsequent valves can be of 20 or 30 henries.

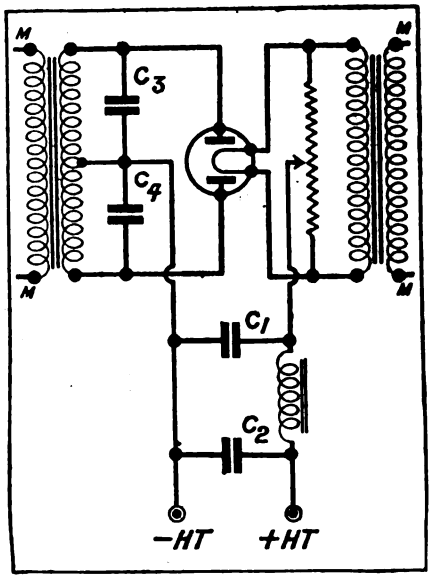

Fig. 2.
Similar circuit to Fig. 1, but using a potentiometer across the filament winding instead of a centre tapping.

For the final voltage adjustments of the output it is best to have a separate resistance and condenser for each tapping point rather than a voltage divider common to all tappings.

These resistances can be the ordinary non-inductive wire-wound anode resistances and their values to give any voltage can quite easily be determined from the well-known formula, volts-to-be-dropped=amps. multiplied by resistance.

(To be continued.)

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The Consolidation of the Peace

By A Student of Progress

Last month our contributor told our readers how the "war" between the B.B.C. and the Television interests came to a conclusion. This month he gives us some further inside information on the present relations between the Baird Company and the B.B.C.

ANSWERING a question in the House of Commons on Tuesday, March 5th, the Postmaster-General made it clear that an independent panel of M.P.s attended on the morning of that day a formal test of Baird television, conducted by the B.B.C. in co-operation with the Baird Company. Although there were pledges of secrecy before this test, and although the formal statement of the result has been delayed, I feel that there is legitimate room for speculation and comment at this stage.

Happily the atmosphere of suspicion and distrust seems now to have been dissipated. At the same time it is necessary to keep in mind certain cardinal factors. There is no doubt that the latest intervention of the Postmaster-General was the result of serious deliberations in the Cabinet, which, on the information laid before it, was gravely concerned to protect and support a great British invention. I have it on unimpeachable authority that the Prime Minister himself was so keenly interested that if circumstances had permitted he would have attended the test on March 5th.

Effects Abroad.

There is good ground for presuming that representations had been made by several British diplomats and trade agents abroad to the effect that the delay in giving support to television in Britain was prejudicing the possibility of a virtual world monopoly of the new science by British interests. It is known, too, that the hold of the American film in India is the subject of concern in Government circles both in India and at home. The development of television under British auspices might have a political significance in several parts of the Empire.

At the time of writing, the names of the Members of Parliament who attended the test on March 5th have not been divulged by the Postmaster-General, and the two Members with whom I have discussed the matter naturally expect me to conceal their identities until they may be disclosed with propriety. It is significant, however, that both these gentlemen are wildly enthusiastic about television, and have voted for the maximum support from the Government and the B.B.C. It is a practical certainty that the panel of M.P.s will report to the P.M.G. in a favourable sense.

So far so good. What will happen then? The P.M.G. is already being heckled in the House about the possible effect on "marketing operations" of any pronouncement of his. There is indeed an incipient movement to prevent his making any statement. This attitude is, of course, based on misconception. The P.M.G. did not intervene to help the Baird Company or to appreciate its shares. I do not

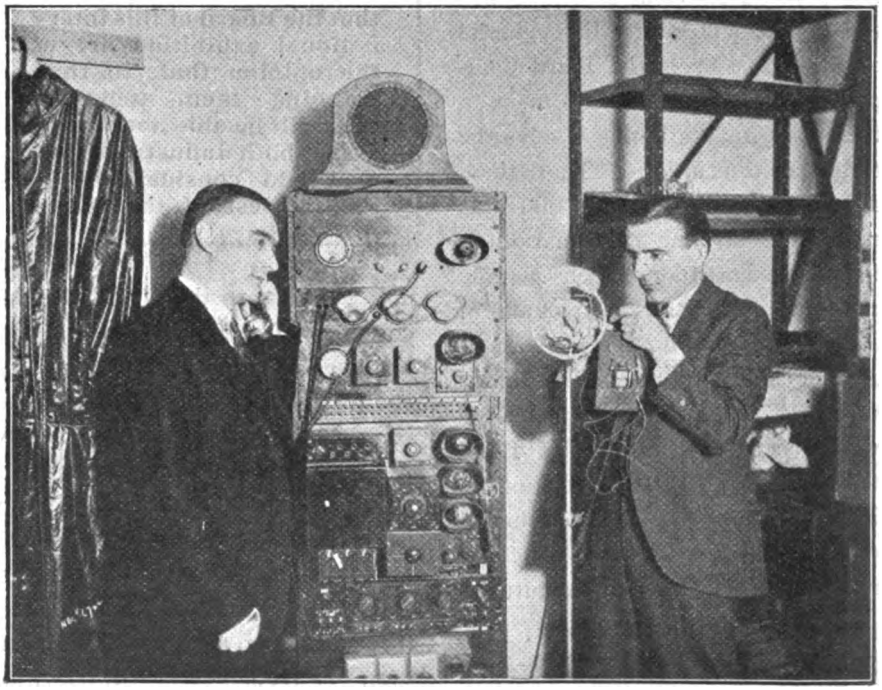

Photo Courtesy National Broadcasting Co., U.S.A.

Engineers of the National Broadcasting Company (U.S.A.) testing a portable control panel and microphone in preparation for the broadcast of President Hoover's recent inauguration.

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suppose Sir William Mitchell Thompson cares a particle about the Baird Companies or their finances.

P.M.G.'s Motive.

His real motive—and a very right and proper one—was to see that British television was given every possible chance at a critical stage of its development. He felt that the issues involved were too far-reaching to be left entirely in the hands of technicians. All this is clear. What is not so clear is the sequel to the test of March 5th. I would venture to prophesy that the value of the favourable verdict on the March test will be more moral than real. In other words, it will give Baird television the approval and blessing of what was virtually a non-party Government Commision. This will strengthen the position abroad, and enable a number of big deals to be put through.

But there will be still some distance to go before television transmissions are given regularly by the B.B.C. I expect that after communicating the favourable view of the panel, the P.M.G. will invite the engineers of the Post Office, the Baird Company, and the B.B.C. to make a fresh start in an attempt to solve the technical difficulties. That these difficulties are no longer taken as vital finds striking confirmation in the changed attitude of such scientific authorities as Professor Appleton, of King's College, who acts as wireless advisor and expert to *The Times*. Only last October, Professor Appleton was writing despairingly of Baird television. But as a result of an inspection the other day, he found it possible to give in *The Times* a really optimistic view of the future.*

Prof. Appleton's View.

It is true that he leans to the land-line system of transmission, but it is a great advance for him to say even of this "there should be no difficulty in transmitting satisfactory television signals, and thus the reproduction of some particular event could take place in a large hall, and be visible to a large audience."

With the engineers all working together in the common cause much will be gained this year. It is a great advance for one thing that Captain Eckersley is meeting Mr. Baird. What a strange thing it is that this event was delayed so long. Even now it is due to the persistence and courage of Mr. Sydney Moseley that the meeting took place. Anyway, the result of this meeting and other concurrent conversations will be new tests by land-line and radio, both private and public. I expect television to slip into the ether without any formal inauguration or blowing of trumpets. Some way will be found for adjusting the waveband; but even so a regular service of television is not quite at hand. Nevertheless, much will have been done, and British supremacy will have been maintained.

Now, in conclusion, one word about the relation of inventions such as television to "City" speculation. There is a great deal of loose thinking on this subject. In the present economic organisation of society no invention can be developed without money, and usually a great deal of money. When a new idea such as television has crystallised in the mind of the inventor, it will die with him unless there is a sound business man to co-operate with the inventor.

The "City."

With the Baird affair there was fortunately the ideal combination in Mr. Baird and Captain Hutchinson. The latter set out to get the "sinews of war." He invaded the City with a scheme which at first glance was considered ridiculous and fantastic. But Captain Hutchinson "stuck it" until he found brokers and investors ready to throw in their lot on the chance that Baird television would be a winner. Companies were floated and large sums of money were made available. It was avowedly and clearly a speculation. Investors stood to make a fortune or lose everything.

Once the money was secured, Captain Hutchinson and Mr. Baird turned all their attention to scientific organisation and development work. They practically forgot about the "market." But naturally the investors and speculators generally kept a close eye on such a unique proposition as television, and there was continuous and buoyant dealing. It is wrong to suggest that there ever has been any share manipulating as such. Baird shares have taken their turn on the market, obeying the fluctuations normal to this class of investment, in accordance with the law of supply and demand.

AN INTERNATIONAL EXHIBITION IN SWITZERLAND.

WE are indebted to M. Claude Schubiger, Secretary of the Swiss Radio Club, Lausanne Section, for the information that an international exhibition of wireless and gramophone apparatus will be held at Fribourg, Switzerland, from September 7th to 15th, 1929. The Wireless and Gramophone industries are now so closely allied that the Board of this international exhibition are of the opinion that, in thus bringing them together, they will be able not only to assist both industries, but also add considerably to the interest of the show.

* See page 70 of this issue.

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Light: The Essential of Television

Part VIII.

By CYRIL SYLVESTER, A.M.I.E.E., A.M.I.Mech.E.

Light is one of the most important factors in connection with television, and one which must be carefully studied by all serious students of television. The principles and nature of light are by no means so widely known and understood as one would anticipate, and in this series of articles our contributor is elaborating them month by month.

WHEN considering the effect of normal daylight upon vision, or the ability of the eye to readily discern objects and their true shapes, it may be said that some kinds of daylight are not as suitable for television purposes as others. When bright sunlight, for instance, is projected upon a woodland scene, we have contrasts of extreme brightness such as light reflected from objects with high reflection factors, and objects situated in dense shadows from which very little light is reflected.

It is very difficult for the eye readily to discriminate between the latter, not only because their reflection factors are low, but because cross reflections are entering the eye from the objects with high reflection factors. Cross reflections, whether obtained through natural or artificial light, must result in loss of vision. In other words, a scene to be broadcast by television must not be illuminated (either naturally or artificially) in such a way that extreme contrasts are obtained.

Directional and Diffused Light.

In normal sunlight dense shadows are produced because the light from the sun is too directional. If a cloud passes over the face of the sun the direction of the light rays is altered; the rays are split up and they reach the earth from different angles from the fact that the sun, which formerly may be considered as a luminous point of raw light, is replaced by the cloud which may be likened to a luminous body radiating diffused light. It is the altering of the light rays which destroys the shadows or, in the case of ideal daylight, makes them soft and luminous.

Although one cannot control normal sunlight, it may be said that when it is diffused it is more or less under control. If the sky is slightly cloudy throughout a whole day the soft shadows of objects will alter in position and depth according to the location of the sun in the sky. The objects are fixed but the position of the sun is not; the shadows will, therefore, vary in position and depth, the latter because the intensity of light will vary. It is exactly the same with artificial light; raw light, or direct light, will produce shadows in which objects cannot be seen or, at least, only with difficulty.

It is with scenes that will be broadcast under artificial light that

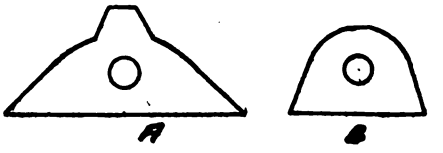

Fig. 1.

we are more concerned at the moment. Here we have an advantage over normal daylight from the fact that we *can* control the light with which a scene will be illuminated. I have already pointed out that the light from a modern gas-filled lamp (the only efficient medium for producing artificial light) emanates from the filament and is radiated in all directions.

By the use of suitable reflecting equipment the upward and horizontal rays can be collected and projected in any desired direction. To effectively illuminate a scene, therefore, the quality and direction of the light must be right. We will consider a few simple principles of light control.

In Fig. 1, *A* and *B* are illustrated two different types of reflectors. The one at *A* is known as a dispersive type of reflector, not altogether from the fact that it disperses the light from the reflecting surfaces, but because it gives a broad distribution of light. If an object were situated at a certain distance from this type of reflector it would be seen in its three dimensions. If the object were located immediately under the reflector, only a very slight shadow would be produced, if any at all; this would depend upon the size of the object.

Effects of Reflectors.

If the object were moved beyond the angle of cut-off between lamp filament and reflector lip, the shadow would be very dense; this because the intensity of light is much lower from the fact that no direct light from the filament is being received, and that the intensity of the reflected light which is received from the *opposite* side of the reflector is very low.

The reflector illustrated in Fig. 1, *B*, is known as a concentrating type reflector. The reflecting surface is exactly the same (in quality of enamel, etc.) as the one illustrated at *A*, but the distribution of light is much different. The angle of cut-off between lamp filament and reflector lip is increased; that is, the lamp is higher in the reflector and, for a certain candle-power lamp, the filament is located higher in the reflector. This has the effect of collecting some of the horizontal light rays and projecting them in a more downward direction. The light, therefore, is more intense or concentrated.

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The intensity of light from either unit is not uniform over the whole of the area illuminated. This makes the design for the illumination of any setting very difficult. The difference in the intensity of the illumination can be seen by consideration of Fig. 2. Here is illustrated a right angle reflector; I have chosen this because it will be easier to follow and because it is, in effect, the conditions which obtain in a circular reflector through its cross section. In this illustration *L* is the lamp and *R* is the reflector.

Angle of Cut-off.

Looking at the top of the illustration the full line shows the angle of cut-off between the lamp filament and the reflector edge. Although this is termed the angle of cut-off it is not the angle at which the whole of the illumination is cut off. A certain amount of light is projected from the bare lamp filament to the bottom of the reflector, from which position it is reflected, or redirected, in an upward direction. This is shown by the broken lines. If this unit is illuminating an object, the latter will, therefore, receive illumination of two intensities—the high intensity of light from the direct rays and the lower intensity from the reflected rays.

It should also be remembered that the intensity of light is inversely proportional to the square of the distance of the light source from the object. From the illustration it will

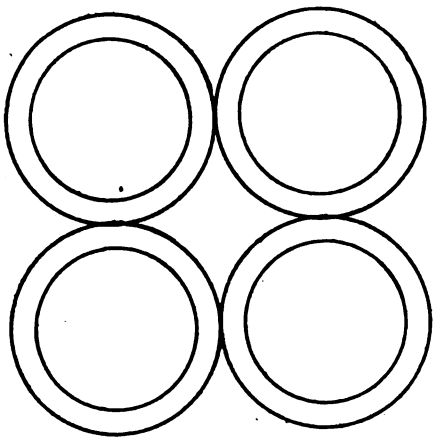

Fig. 3.

be seen that the area of the object illuminated by the light of low intensity is much further away from the light source (the reflecting surface) than the area illuminated by direct light from the filament. The difference in intensity, although the reflection factor of the reflecting surface may be as high as 85 per cent., would be about 50 per cent. That is, assuming an intensity of 8 foot-candle on an object from the central beam, the intensity of light from the outer beam would not be more than 4 foot-candles.

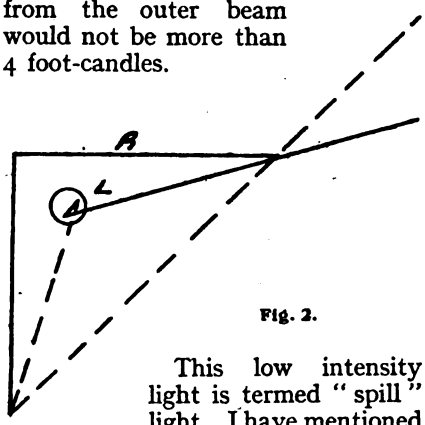

Fig. 2.

This low intensity light is termed "spill" light. I have mentioned a variation of 50 per cent. in the two intensities. If this could always be obtained some of our lighting problems would be simplified. I would say, however, that the difference in the intensity of the spill light depends upon the type of reflector from which the light is obtained. In the reflector illustrated in Fig. 1, *B*, the area of the spill light would be considerably less than with the reflector illustrated at *A*. The intensity, therefore, relative to the main beam, will be higher.

Multiple Light Sources.

It has long been realised that even illumination cannot be obtained with an even spacing of lighting units. This is why so many different types of units are available for stage lighting. The unevenness of illumination from, say, four lighting units of the same type and candle-power can be seen by consideration of Fig. 3. In this illustration is shown the distribution of light, directional and spill, from these units. The low intensity areas are just touching; it will be seen that a large portion in the centre of the total area is receiving no illumination. If the spill light area is covered, as illustrated in Fig. 4, the illumination is much more even although there is still an appreciable area which is not illuminated to its proper intensity.

The effect of uneven illumination upon a setting can be seen if the matter is considered from several viewpoints. First, let us assume that a portion of a setting is to be illuminated from a unit situated immediately above it. If the section of the setting is large, beyond the area of the unit, the section is not evenly illuminated. There may be the correct intensity of light for the centre of the setting, and the direction of light (the unit would be located slightly out of centre) may produce the right amount of light and shade, but the edges of the setting would be illuminated to a low intensity and, what in the centre would be seen in its three dimensions, would appear with dense shadows towards the edge. To fit four lighting units, as illustrated in Figs. 3 and 4, would reduce the shadow at the edge of section but the centre would not be clearly illuminated.

Even Illumination.

The remedy depends upon the location of the setting and the reflection factors of the objects surrounding it. With regard to the location of the setting, I am referring to the relative positions of the setting and the units with which the setting is to be illuminated. Referring again to Figs. 3 and 4, I would say that the distribution of light holds good only when the edges of the reflector are parallel with the face of the setting. In the example the units are situated immediately above the setting. If the units were slightly out of the hori-

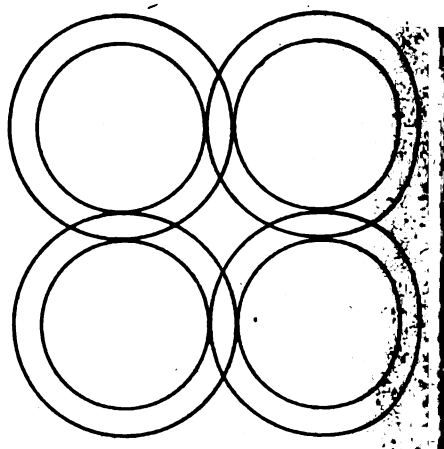

Fig. 4.

zontal position the distribution of light would no longer be circular, it would take the form of an ellipse.

I will deal with methods of correcting uneven illumination in my next article.

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The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

Part. IV—SUBMARINE TELEGRAPHY

IN addition to the Atlantic cables dealt with in the last article a most important system of cables from the British point of view is that owned by the Eastern Telegraph Company and its associated companies. This system connects Great Britain with India, Australasia, the Far East, Africa, and South America, and is the largest and most important cable organisation in the world. The system is concentrated at this end, at Porthcurno, near Penzance, and the huge amount of traffic dealt with can be judged from the fact that the cables running out eastward from Porthcurno carry some 70 million words a year. The total length of the cables owned by the organisation is about 136,000 miles, and their importance to the British Empire is obviously incalculable.

Across the Pacific there are two British cables connecting Vancouver with Australasia, and one American cable connecting San Francisco with the Far East. The British cables are owned jointly by the Imperial, Canadian, Australian, and New Zealand Governments, but will be transferred to private enterprise under the merger scheme. The section between Vancouver and Fanning is the longest cable section in the world, nearly 3,500 miles.

This country is thus linked up with Australasia and the Far East by submarine cables, on the eastern route via the Indian Ocean, and on the western route via the Pacific. In addition there are available two transcontinental routes, mostly overland, one, via North Russia, largely owned by the Great Northern Telegraph Company of Denmark, and the other, via South Russia, largely owned by the Indo-European Telegraph Company of England.

These are the main cable systems, and it is unnecessary here to consider the vast network of lesser systems which spreads out all over the world. The total length of cables now working is about 350,000 miles, of which about 265,000 miles are long-distance cables and 85,000 miles are short-distance cables. Of the long-distance cables, about 144,000 miles are British, 85,000 miles American, and the rest various.

The Cable-Wireless Merger.

Over three-quarters of the cable mileage of the world is owned by private enterprise; the remainder, consisting for the most part of short cables, is owned by the various governments. In this country, as already mentioned, the Government does own two of the older Atlantic cables, and has a share in the ownership of the British Pacific cables and the British West Indian system, but it has been decided to transfer these cables to a communications company now being formed.

This company is the outcome of the report of the Imperial Wireless and Cable Conference, which was published last July. The conference, which included representatives of the Imperial Government and of the Governments of Canada, Australia, New Zealand, South Africa, the Irish Free State, India, and the Colonies and Protectorates, had been appointed to recommend the adoption of a common policy in view of the situation which had arisen as a result of the competition of the new beam wireless services with the cable services.

The report unanimously recommended a merger scheme to amalgamate in one undertaking all cable and wireless interests conducting communications between the various parts of the British Empire. This new company will take over the cable and Marconi companies

Laying the shore end of a cable at Cerro, Montevideo. The cable was hauled ashore by horses and men

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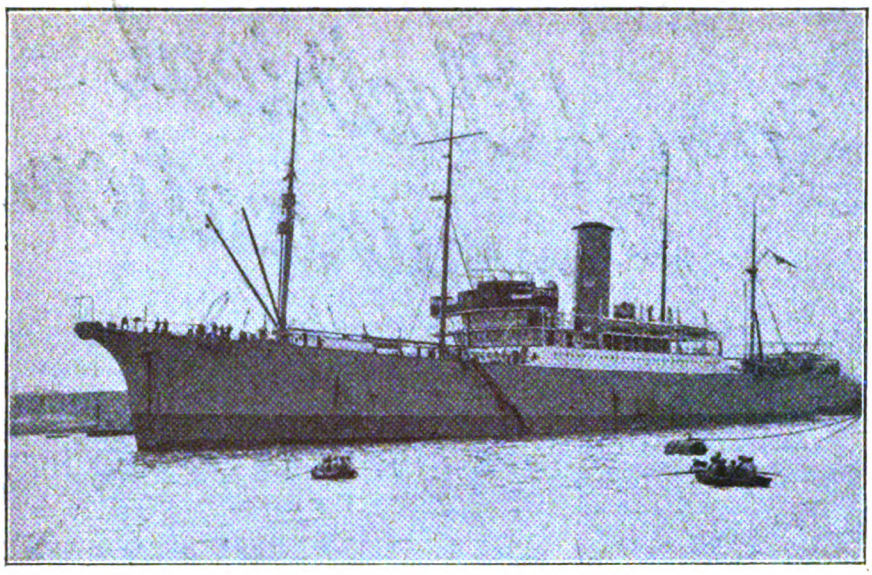


The new cable ship "Dominia," which laid the latest cable.

concerned, the British Pacific and West Indian Cables, the two Atlantic cables which are operated by the Post Office, and the Imperial Wireless beam services which, in this country, are also operated by the Post Office.

The chairman and one of the directors of the company must be approved by the Government, and all questions of policy, including alterations of rates, must be submitted to an Advisory Committee comprised of the representatives of the Governments concerned. British control of all the companies must be guaranteed, and in case of national emergency the Governments may assume control of the systems.

This merging of cable and wireless interests for the communications of the British Empire is a most important milestone in the development of electrical communications. It introduces a new era, not only in our communications, but in the communications of the world. The whole idea is looked at askance in some quarters, but when all is said that can be said, it does appear to be based on what we like to think is so eminently British—sound common-sense.

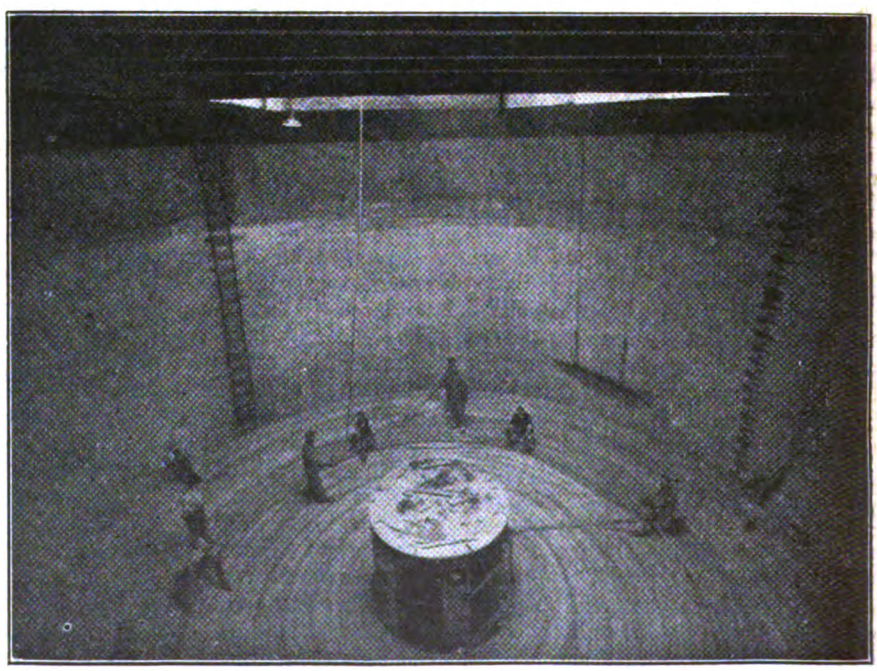
We have so far been considering cable developments broadly from the outside, and it may be of interest now to take a rapid bird's-eye view of the technical progress which has taken place since the Atlantic cable became a commercial proposition sixty years ago.

A submarine cable is electrically a large condenser, the conductor forming one plate, the insulation forming the dielectric, and the wire sheathing and water forming the other plate. A cable has therefore a large capacity, and takes a considerable time to charge and discharge, which retards the rate of signalling. This was the first great bugbear of cable telegraphy, and is the principal reason why so far it has been found possible to use telephony only over short distance cables.

Various devices were, of course, invented to improve matters from time to time, but until quite recently speeds of about 30 words a minute, duplex working, were all that could be obtained. Many improvements were made in the manufacture of cables, but the general form remained essentially the same. The conductor consisted of a central wire of pure annealed copper surrounded spirally by smaller wires to give it greater flexibility, the total diameter being about half that of a lead pencil. Around this, and of about the same diameter, was the dielectric, gutta-percha applied in plastic form; over this was the protective covering of jute, and, lastly, the sheathing of iron wires around which was wound jute, impregnated with a compound of pitch which is more or less impervious to water.

At great depths there is little trouble with the cable, which lies buried in the ooze on the bed of the ocean, but as the depth of water decreases the bottom of the ocean becomes rougher, and troubles arise from the activities of fishing trawlers and the like. For this reason it is necessary for the sheathing of the cable to be much stouter at the inshore ends, so that a cable which weighs two tons a mile in its deep sea portion may weigh as much as twenty tons a mile near the shore, where its diameter may be increased to as much as two inches.

The laying of a cable has now reached such a state of perfection that the most recent one, which was laid in September last between



How a cable is coiled in a ship's hold.

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Newfoundland and the Azores, a cable length of 1,341 miles, was working eight days after the expedition had started from Newfoundland.

The New Cables.

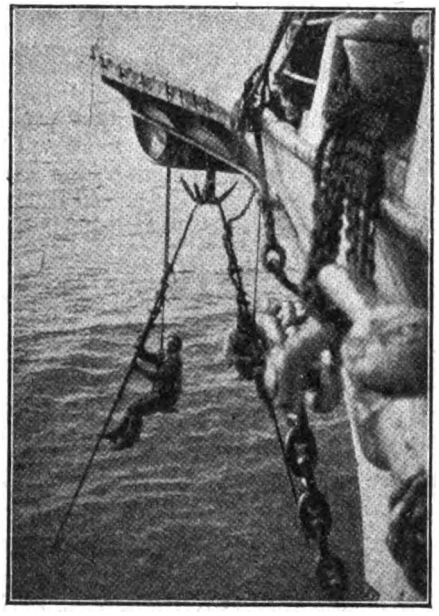
It was not until after the war that the phenomenal advance of wireless made the cable companies sit up and take notice. But they did not sit for long; they got busy, with the result that cable telegraphy has advanced more in the last five years than it did in the previous fifty. The pioneer honours for the new type of cable indubitably rest with the engineers of the Western Electric Company of New York, who initiated the first long-distance loaded cable. There were, of course, others to whom great credit is due, notably the Telegraph Construction and Maintenance Company of London, Dr. Wagner of Germany, and last, but certainly not least, the late Oliver Heaviside of England, who had laid the theoretical foundations many years before.

The first long cable was laid by the British Company in the summer of 1924 between the Azores and New York with the coöperation of the Western Electric Company, who provided their loading alloy, which they called "Permalloy." The results exceeded all expectations, a signalling speed of nearly 400 words a minute, simplex, being obtained. Permalloy is an alloy of nickel and iron, and is wound round the core in the form of a thin narrow ribbon. This increases the inductance uniformly throughout the length of the cable, and neutralises, to a great extent, the troubles which arise from capacity. The British Company soon produced another suitable alloy, called "Mumetal," and the Germans still another, but the American company were the first in the field.

Since 1924 all new long-distance cables have been of this loaded type, and the signalling capacity of each cable has been four or five times as great as would have been the case with the old unloaded type. But these new cables have not been suitable for duplex working at high speeds, as the older ones were at low speeds, and this was, of course, a great disadvantage.

However, the American Company has again come to the rescue with what is called "tapered" loading, which consists essentially of having heavy loading in the middle section, gradually tapering off towards the ends, the final lengths being of the old unloaded type. The Newfoundland–Azores cable, laid last September, was of this type, and duplex working at high speed is possible; that is to say, messages can be sent at high speed from one end whilst messages are being received at high speed from the other end.

The general principle employed in duplex signalling is to arrange so that the signals from a station are sent not only over the line, but also into an artificial line, consisting of capacities and inductances with the same characteristics as the real line, and of timing resistances. If the signals were sent from one end over the line only, they would, of course, affect the receiving instruments at that end,



A cable being raised.

so that messages could not be received at the same time from the distant station. But if the signals sent into the line are cancelled out in the receiver by the same signals sent into the artificial line, the receiver remains unaffected, and is capable of responding to signals from the distant station.

Although the older loaded type of cable cannot be used for duplex working, it can be used for multiplex working, first in one direction and then in the other. In multiplex, the cable is automatically connected in turn to a number of transmitters at one end, and, by synchronised apparatus, to the same number of receivers at the other end. With this arrangement a cable which can carry 400 words a minute would give four channels, each capable of dealing with 100 words a minute; and four messages coming in at the same time at 100 words a minute can be much more easily handled than four messages coming in, one after the other, at 400 words a minute.

The latest tapered type of loaded cable can, however, be worked duplex, the messages being sent too on the multiplex principle; that is to say, a number of messages can be sent at the same time as a number of messages are being received; in fact, the conditions of signalling over the latest long cables now approximate to those of signalling over land lines.

Modern Practice.

The transmitters used are of the Wheatstone type, arranged to send positive and negative impulses instead of the dashes and dots of the morse code. In some cases the syphon recorder is still used for reception, but in others, apparatus is used for converting the cable signals into the dots and dashes of the ordinary perforated slip. This slip is then run through a Creed printer, which produces the messages in printed form on a paper tape.

These developments in operation have come about gradually, but the really outstanding advances in working the older cables were due to the introduction of duplex working, the Heurtley magnifier, telephony over short cables, and, within the last five years, the regenerator. Heurtley's magnifier increased the size of the received signals, and by its use the speed of signalling was increased by about 30 per cent. The regenerator, which restores the signals to their original condition before passing them on to the next place where the cable lands, thus overcoming to a great extent the effects of distortion and attenuation, increases the speed by about another 30 per cent.

To sum up, it might be said that until five years ago the outstanding advances had been the introduction of duplex working, the Heurtley magnifier, and telephony over short cables; whereas in the last five years we have had the loaded cable, the regenerator, and the tapered loaded cable. The loaded cable introduced high speed working, the regenerator increased substantially the speed of working over the older cables, and the tapered loaded cable introduced high speed duplex working, and indeed will soon introduce long-distance cable telephony, the "crock of gold" of the submarine cable.

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The Progress of Television.

— More Detailed Images —

Through the courtesy of the Editor, we reproduce below an article which appeared in "The Times" of March 7th last.

ONE of the most discussed technical problems in connexion with the broadcasting of television is the correct assessment of the "spread" of wavelengths round the nominal value which is necessary to transmit an image which is tolerably satisfactory in detail. It is, of course, known that, by increasing the number of wavelength channels used, it is possible to increase the amount of detail practically without limit, but, from the point of view of a system of home television, it is of more importance to know what can be done with the minimum band of frequencies. In the event of the establishment of a television broadcasting service it would be necessary for the authorities to specify the limits of the band of frequencies used, so that no interference should be caused to other services.

The frequency range used by an ordinary broadcasting station is a calculable quantity, and its magnitude has determined how close together in frequency stations may be allowed to operate. It is usually considered that a telephony station should be able to transmit satisfactorily a musical note as high as 10,000 cycles per second, and when doing so it would send frequencies differing from (both above and below) its mean value by that amount. The important question, therefore, from the standpoint of the broadcast television service is whether a service that would satisfy the "looker" could be provided with a range of frequencies comparable to that just mentioned. Everything depends on how much the eye will tolerate in the way of lack of detail, flicker, &c.

A recent demonstration of television at the Baird laboratories has raised again the question of the necessary minimum frequency range, for an excellent head-and-shoulders reproduction was witnessed by the writer on a land-line transmission for which the frequency range was stated to be only 10 kilocycles. The television image was received on one of the more expensive sets which may now be ordered, and it did not seem difficult to "tune in" the picture and "frame" it correctly by means of the two controls. Great progress has been made both in increasing the detail of the image and in securing stability of the image since the demonstrations at the Wireless Exhibition last year. An experimental fact in this connexion may be quoted. A watch (of the rather large "turnip" variety) was exposed to the television "eye," and the present writer read the time as one minute to three. The actual time was ascertained to be one and a half minutes to three.

The high tension voltage required for the home television sets is 350 volts, a rather high value when compared with that required for an ordinary wireless set. But against this it may be pointed out that with alternating-current mains the production of such a high tension supply by means of an eliminator is an easy matter. At present the sets are designed for a fixed wavelength of 200 metres, which has been the wavelength on which experimental transmissions have been made.

The question of the inauguration of a television broadcasting service, which is being considered by Post Office officials at present, is naturally the foremost question in connexion with "television in the home," and to some extent overshadows the question of "television in the theatre." Many methods of carrying out the latter project have been considered, the most feasible being that of having a screen made up of a large number of small lamps. The lamps are so small as to be invisible individually, but each forms part of the reproduced image, being light or dark according to the particular elements in the original image which it represents. With high quality overhead land telephone lines there should be no difficulty in transmitting satisfactory television signals, and thus the reproduction of some particular event could take place in a large hall and be visible to a large audience. For such a service the rather large performance factor of safety necessary in home television sets could be dispensed with, for it could be worked throughout by experts.

SHOWING THE POLICE THE WAY TO TELEVISION.

Professor Arthur Korn tells me that his system of photo-telegraphy has now been definitely adopted by the German police, and sets of apparatus are being installed in Berlin and Breslau.

Long tests have been undertaken. Fingerprints and photographs of wanted men have been transmitted—how successfully, this picture shows.

In this latest improved apparatus Professor Korn still retains his string galvanometer method of varying the intense beam of light directed on photographic paper or film wrapped round a revolving cylinder in a light-proof case.

At the sending end a photo-electric cell intercepts the light reflected from the picture being transmitted, which is traversed, as it spins on its cylinder, by a fine point of light.

Synchronisation is obtained by the use of synchronous motors.

The picture is transmitted and received in one minute, and this means, Professor Korn pointed out, dealing with 5,000 picture units a second.

"Eventually 100 police stations in different parts of Germany will have radio picture sending and receiving sets," he said.

"In addition to fingerprints and portraits, the police will transmit their telegrams as wireless pictures. This will save time, and the obtaining of a facsimile of the actual message will take away the possibility of error."

WILLIAM J. BRITTAIN.

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Civilisation and Television

By HOWARD HAVELOCK COX

Editor of the "Power Times," and formerly A.D.C. to Commander R. E. Byrd, U.S.N., the Polar Explorer.

TELEVISION was as inevitable as the bee-hive. Evolution produced both. But their starting-points are widely separated. The bee-hive had to come first. The gap between them must be written off in terms of the "fullness of time."

Even now, television has come too soon. The generation which regards wireless as a matter of course takes television too much for granted. The one invention has followed too quickly on the heels of the other. The modern age, stifled by its sense of power, has lost all conception of values. It is unworthy of the great trust devolving upon it. Often it fails to recognise that trust at all.

It is disquieting to realise how singularly non-productive the average human really is. The mass owes its comfort to the insight and productiveness of the few. It is the genius of the age whose inventive resourcefulness has made television practicable. The mass of mankind is still drifting through the coma of intellectual sterility.

The long period of helplessness characteristic of early childhood has its counterpart in the early stages of civilisation. In our day there are evidences that that stage is passing. Man is beginning to help himself.

The evolution that set up the physical conditions which made television possible, also developed the keen, pursuing mind capable of recognising those conditions, no less than the ability to co-ordinate, harness and direct them. Television plunges into our contemporary civilisation. What do we know of the internal stresses and strains governing that civilisation's society? If we can lay our finger upon them, the advent of television may bristle with hitherto unsuspected significance.

Contemporary life has produced an alluring social round. Its influence reaches through all classes and its insistent fascination leads countless humans to mistake it for life itself. The functions of society have their birth in the individual wish to break away from reality. The chief job of society is to camouflage the real self. And since society is full of people who are trying to forget themselves, its functions are tantamount to intoxication.

Commander R. E. Byrd, U.S.N., who, having already flown over the North Pole, is now engaged upon an expedition into the Antarctic region.

"There is a strange allurement about discovery which leads men ever on in the search for something new."

Civilisation is a terribly artificial thing. There is nothing like it in nature, so-called. Yet humans knowingly chain themselves down to its meaningless conventions. And what sacrifices are made to that end! Genius and character are suffocated by institutionalism. The span of life is spent in acting a part which is an insult to the sincerity of existence.

Look at this strange humanity through a magnifying glass. Go to Piccadilly and watch its soulless hordes of parasites as they cling timidly to the outer strands of reality. How little they know of life—how little of themselves! To them reality is ugly, disturbing, unromantic.

It may seem a long cry from the foregoing to the essentially practical subject of television, yet the connection is definite and outstanding. Much has been written about the mechanics of television, little of its implications. Television gets home on two main points. It provides a new means of self-forgetfulness and meets the demands of man's eternal, deep-rooted curiosity. There lies its potentiality. That is its trading basis.

Human nature exhibits a quaint curiosity to know what the other fellow is doing. Wireless telephony seemed at first to provide the long-felt want, but soon it brought with it a feeling of its own inadequacy. Man's finest sense remained ungratified. Eye-gate was straining to take the place of imagination.

Of the scientific inventions of our time, television must be placed in the front rank on account of its immediate appeal to the family

(*Continued on page* 80.)

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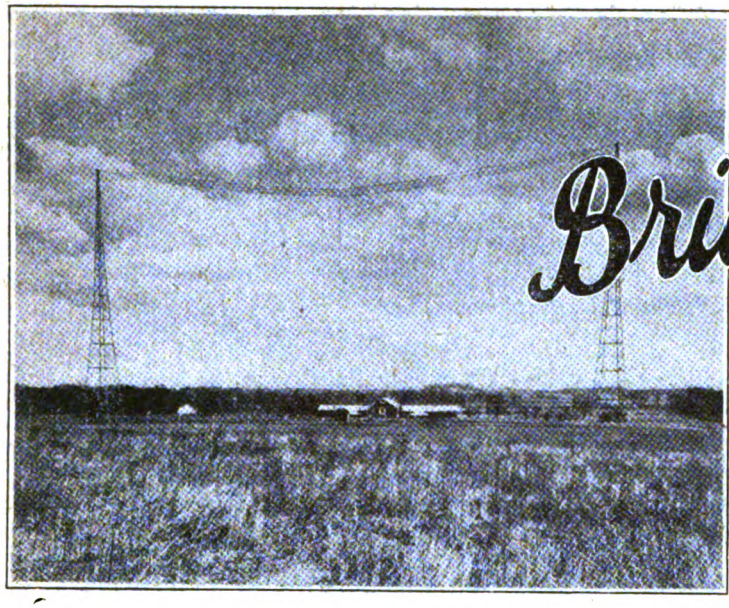

Bridging Space

by

JOHN. WISEMAN

Part X.—THE RECEIVER

WE concluded last month's instalment of our series with an introduction to the elements of rectification, and we saw that this process was an essential factor in our chain of events if the signals picked up by the receiving aerial were to be made perceptible to the ear (we are dealing with the speech case first). Provided the reader thoroughly assimilated the facts of the simple case that was illustrated he will be in a position to appreciate the broader details which it is now essential to place before him.

An Assumed Modulation.

For the purposes of explanation it is immaterial what form our modulated carrier wave takes, since we know that the e.m.f. set up in the receiving aerial due to the electromagnetic waves emanating from the transmitter will be an exact reproduction of the current in the transmitting aerial. Let us suppose then that the modulated wave produced a voltage in our aerial similar to that shown in Fig. 1. The curve is drawn so that the modulating envelope represents a short period when the microphone is being activated by, say, speech, song or music, while the horizontal part of the envelope indicates that the microphone diaphragm is actually at rest owing to the absence of any sound waves impinging upon it.

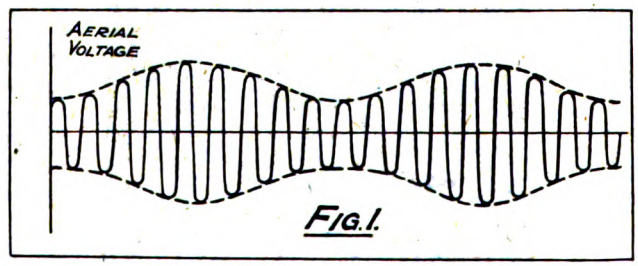

Fig. 1.—A modulated carrier wave.

Detector with Linear Characteristic.

To retain the extreme simplicity of our explanation and yet obtain a clear exposition of the principles, we will assume that the characteristic of the rectifier we are employing in our receiver is as indicated in Fig. 2. From this it will be seen that we have a linear characteristic which obviously will give a positive current varying directly with the magnitude of the impressed positive voltage, but which registers zero current irrespective of the amplitude of the negative portion of our e.m.f.

Actually, the rectifiers used in radio receivers, whether crystal or valve, have characteristics which cause a current variation proportional to the square of the impressed voltage, but the assumption of a straight line characteristic involves no change in fundamental principles so far as signal reception is concerned, and since it simplifies our diagrams and explanation it has everything in its favour as far as interpretation by the reader is concerned.

Unidirectional, but Pulsating.

With the simple receiving circuit of Fig. 3, therefore, consisting of an aerial coil tuned by a variable condenser to produce resonance with the incoming signal wavelength (or frequency), which in turn passes on the voltage impulses to the rectifier R and the telephones, what is going to happen?

Obviously, the current produced in the rectifier circuit (which includes the headphones) must be unidirectional, owing to the action of the rectifier. The formation of the current variations produced by the Fig. 1 voltage curve is now that of Fig. 4A. This unidirectional curve is still pulsating at a very high frequency and in consequence, of itself, cannot produce any movement of the telephone diaphragm, for, as we mentioned previously, its inertia precludes such a happening. These rapid unidirectional impulses will produce an *average effect*, however, in much the same way as a series of light blows with a hammer on the head of a nail bring about the same state, as far as work done is concerned, as heavier blows at a slower rate.

An Average Change at the Modulating Frequency.

We shall have a building up and dying away of the current in the telephones, or, in other words, an average rectified current as illus-

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trated in Fig. 4A. What do we notice from an examination of this last curve? Why, that the average change of current is taking place at the frequency of modulation and

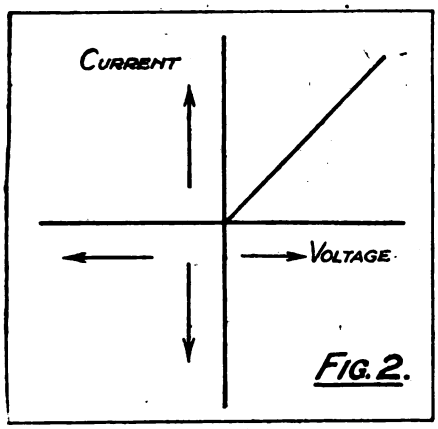

Fig. 2.—A simple rectifier characteristic.

when the microphone diaphragm is at rest the rectified current is steady. Now this modulating frequency is our speech, song or music frequency, and in consequence the diaphragm of the telephone receiver will vibrate according to the current variations in a manner identical to that of the microphone diaphragm. In other words, we have a duplicate at our receiving station of the initial conditions produced at the transmitting studio.

Of course, the magnitude of the resultant air vibrations produced by the receiver diaphragm, and hence the volume of sound resulting therefrom, is dependent upon the magnitude of the voltages induced in the receiving aerial and the type of receiving set employed, that is to say, whether the receiver is one capable of amplifying the signals

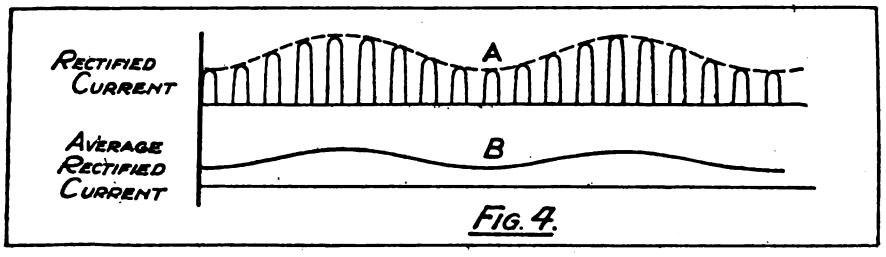

Fig. 4.—Curves of received and rectified current.

both before and after rectification by the established practical methods.

What of the Complex Wave Formation?

Apart from this aspect, however, we have traced the transmission of an assumed regular diaphragm movement and seen how we can reproduce this at the receiver end. The thoughtful reader is sure to ask whether the actual exceedingly complex vibrations of the microphone diaphragm are likely to follow the same process as the simple wave form we have shown. The answer is yes, but a complete technical exposition of this would be out of place in the simple series which we are following.

Suffice to say that any complex wave formation can be analysed into an infinite number of harmonic components of different frequencies, different amplitudes and bearing certain phase relations to one another. These individual analysed harmonic components, of themselves possessing simple "wave" formation, will be reproduced at the receiver diaphragm with changed amplitudes, but the percentage change will be identical for every component frequency. In consequence, we shall have identical speech, singing or music produced at the receiver end of the "space bridging" mechanism.

Taken for Granted.

When we say identical effects will be produced it is taken for granted that any amplification that may take place in the receiving set is such that all modulating frequencies within the speech range will be amplified to the same extent. We all know from the bitter personal experience either of our own sets or those of our friends, that the distorted sounds emanating from some loudspeakers or telephones prove that distortionless amplification is not taking place. By properly choosing the constants of the receiving set and by careful design we can secure distortionless amplification and reproduction, and this is a side of the subject that merits the careful attention of all users of wireless receivers.

Carrier Wave Indispensable.

The intensity of the received aerial voltages is dependent upon many factors—distance between transmitting and receiving stations, wavelength or frequency of the carrier wave, aerial heights, absorptions, etc.—but many of these are beyond the control of the listener. He must fulfil his quota by seeing that the erected receiving aerial possesses maximum efficiency, while the set should be one capable of performing its normal function in a thoroughly satisfactory manner.

The use of a high frequency carrier, that is, one well above the highest important speech frequency (which is in the neighbourhood of 5,000 cycles per second), is essential to the success of our system, although many experimenters have tried to dispense with it. Their failure is attributable to one cause, namely, that only negligible power can be radiated from an aerial even of large dimensions which is actuated directly by currents of audio frequency in, say, the manner shown in Fig. 5.

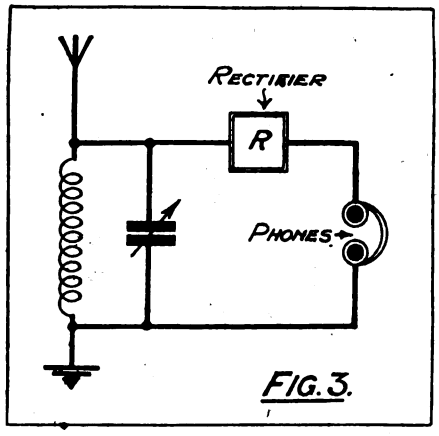

Fig. 3.—A simple receiving circuit.

Obviously, the form of high frequency generator chosen to supply the carrier wave must not, in itself, be capable of interfering with the normal modulation, otherwise this would be heard in the receiver as an unpleasant background.

Television Modulation.

We are now approaching the final link in our chain of events between "studio and fireside," namely, a short consideration of the actual receiver itself, but before so doing it will be interesting to deal quite briefly with the scheme adopted in the Baird system of television for modulating the carrier wave and thus transmitting pictures.

The subject is scanned by a spot-light which divides the scene up

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into a number of elements, and the resulting picture elements or light impulses act upon photo-electric or light-sensitive cells, which transform them into electrical impulses. Now the output from these cells varies in direct proportion to the intensity of the light flashes falling upon them, and after passing through a special amplifier the resultant electrical impulses are made to modulate the high frequency carrier wave of the transmitting station.

Similarity.

The processes for broadcasting speech or televised images are therefore similar as far as the modulation is concerned, and at the receiving end of the system there is a special receiving set which rectifies the modulated carrier wave in a manner resembling that just described for

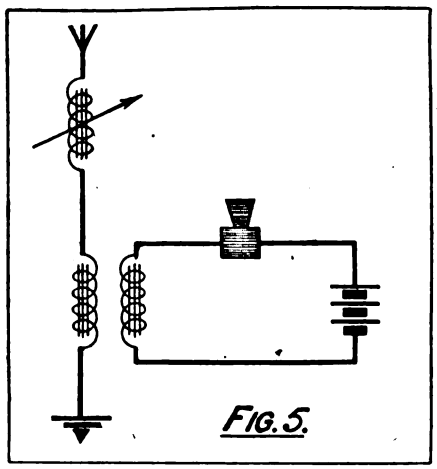

Fig. 5.—An early method of transmitting speech by wireless.

ordinary speech. Instead of the rectified impulses being brought to bear upon a sound reproducing mechanism, however, they pass through the televisor and, by means of a synchronous disc and a neon tube, the disintegrated image sent over by the carrier wave is re-integrated and appears complete with tone gradations of light, shade, and detail.

We see, therefore, that provided we get our fundamental principles correct we can apply them successfully to the better understanding of wireless transmissions, since they have so many details in common. That being the case, we will study the process of amplification in our next month's article and see how the induced voltages in the receiver aerial can be amplified before being rectified, and also what conditions have to be satisfied if further amplification is desired after rectification has taken place.

Television Progress

The following appeared in the "Electrician" of March 8th and is of special interest to members of the Television Society.

The Television Society is to be congratulated upon the comprehensiveness of its first exhibition, which was held at the Engineers' Club, London, on Tuesday. The exhibits covered practically every phase of the science, and indicated in a very practical way the progress which has been made. Though perhaps most of us are inclined to look upon television as being a comparatively recent invention, it was a surprise to some to find among the exhibits apparatus developed some 47 years ago, which gave much the same results as are at present obtained, without the modern improvements brought about by valve amplifiers, etc. A still greater surprise, perhaps, was to be found in the fact that the designer of this early television equipment was no less a personage than Mr. Ll. B. Atkinson who, standing beside his exhibits, gave an altogether delightful explanation of the purpose of his apparatus, and demonstrated its use. The holding of a television exhibition this week is particularly appropriate, for the Post Office last week witnessed a demonstration of a commercial system, the results of which are now under consideration. Among those seen at the exhibition was Mr. J. L. Baird, whose system, now operated by a limited company, is claimed to have progressed so favourably that images and scenes transmitted and received have attained a degree of perfection which is truly remarkable, whether transmitted over a metallic circuit or by wireless. Whether or not we could agree with this conclusion we cannot say, for we have never yet been permitted to witness a satisfactory demonstration. We can say, however, that the exhibition was most interesting and the claims of the exhibitors reasonable, while every facility for investigation was offered.

Civilisation and Television

(*Concluded from page 77.*)

circle. It provides endless profit and pleasure in return for minimum effort. It walks right up to our own firesides and brings the world before our eyes. Thus television definitely helps to re-establish home-life.

The fact that England is on the edge of Europe is full of signficance in visualising the development of this invention within our own country. One can foresee the opening up of a better understanding between our European neighbours and ourselves. We shall learn in a way otherwise impossible something of the habits and customs of our Continental friends. Similarly they will learn more about us. The development and application of the invention to international transmission across the world suggest possibilities which need no elaboraton here.

We have considered television as a source of entertainment and unity in the home. But what of its more severe implications and uses? Television would have been more than justified had its functions extended only to the satisfaction of man's curiosity. But it does far more. What, for example, of its place in the pursuit of business, the activities of politics, the detection of crime or the extension of education? We can safely prophesy television a rich future.

As is so often the case, there is a grave danger of losing sight of the genius behind the invention. We welcome the advent of the steam-engine and forget James Watt. We hail the convenience of the telephone and forget the name of Bell. When using our multi-valve wireless receiver we forget the name of Fleming.

Behind television there is a creative mind of outstanding ability. Surely we can never disassociate the name television from the name Baird. Our gratitude to him should be very genuine, for he has blazed a trail of inestimable worth to us and to posterity. There is a strange allurement about discovery which leads men ever on in the search for something new. But there can be no search without sacrifice. Invention is only accomplished by hard work in the small hours, and television is no exception. Its practical appeal should call forth a practical response on the part of those bodies best fitted to encourage it and assist in its development.

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The Story of Chemistry

Part VII

Electrolysis

By W. F. F. SHEARCROFT, B.Sc., A.I.C.

CONSIDERATION of the family of substances, which the chemist calls salts, leads us to a fundamental point in chemical theory and practice. The first impression which we gather is one of confusing possibilities. We see that there can be so many different salts. The list of acids is as long as one's arm, and from each acid we see the possibility of a salt by combining its acid radicle with a metal. Then each of these salts has its own peculiarities, and it would seem an impossible feat of memory to know what the salts will do under various conditions.

It must be admitted that the possibilities are far too great for human comprehension, but fortunately there is a simplification which we can comprehend. Let us take a concrete illustration. Sodium chloride is a simple salt—simple in the sense that it contains only two atoms in its molecule—*NaCl*. Silver nitrate is another simple salt, with the formula $AgNO_3$. Now let us consider what will happen if we mix these two substances, and assume that chemical action will take place between them.

Results of Chemical Actions.

Chemical actions mean the production of entirely different substances than those with which we start; that is, we shall end up with different molecules. Further, we know that chemical action does not take place under just *any* set of conditions. These two substances are both crystalline, and if we mix the two kinds of crystals, nothing happens. If, however, we first dissolve both the sodium chloride and the silver nitrate in water, and then mix the two solutions, we hit the conditions under which chemical action does take place.

Now let us think of the possibilities. From the molecules *NaCl* and $AgNO_3$ we have to produce a new set of molecules. We start with seven "bricks"—the seven atoms in these molecules. Anything *might* happen. The sodium atom *might* join up with a silver atom, a nitrogen atom *might* join up with a chlorine atom, an oxygen atom *might* join up with a sodium atom, and——but you can go on in this way until you are tired. You can arrange those seven atoms in so many ways that any suggestion that you could remember all the possibilities would be absurd.

THIS is the seventh of our contributor's articles on the story of chemistry, written in simple language, with the introduction only of those chemical formulæ as are essential to an understanding of the subject. In his last two articles he dealt with chemical families and their various relationships. This month he gives us some more information about salts, and explains some interesting facts about electrolysis.

If we carry out the experiment, then on mixing the two clear solutions, a solid substance is produced which settles down in a flocculent mass to the bottom of the vessel, and a clear liquid is left above it. The solid substance is white; it is insoluble in acids, and it darkens on exposure to light. On analysis it proves to be the substance silver chloride, and has the formula *AgCl*. The clear liquid on evaporation gives a crystalline substance which is recognised as sodium nitrate and has the formula $NaNO_3$.

We can write a summary of this action thus: Silver nitrate+sodium chloride → silver chloride + sodium nitrate, or in formulæ—

$$AgNO_3+NaCl \rightarrow AgCl+NaNO_3$$

If we look carefully at this result we see that, of all the many possibilities, actually a very simple one has taken place. The two metals have simply exchanged radicles. The nitrate radicle, which was attached to the silver atom, is attached to the sodium atom after the action is complete.

Exchange of Radicles.

Now this simple exchange of radicles is found not to be confined to this one example, but to be general for chemical actions between salts, *as long as the action takes place in water solution*. It does not matter what the salts are at all. If solutions in water are made of them and mixed, then if chemical action takes place there is a simple exchange of radicles. Here are a few more simple examples.

$$AgNO_3+KCl \rightarrow AgCl+KNO_3$$
$$CuSO_4+Na_2CO_3 \rightarrow CuCO_3+Na_2SO_4$$
$$CaCl_2+(NH_4)_2CO_3 \rightarrow CuCO_3+2NH_4Cl$$

This is a simplification which is easily remembered, and which enables us to forecast what will happen in cases which we have never examined practically. Perhaps it would be better to say, which *might* happen, because there is always the possibility that no chemical action will take place. We shall see that there is a further simplification that will help us here.

This general action has been still further extended, because it applies also to reactions that take place between acids, bases and salts. Thus, for example, if we mix solutions of hydrochloric acid and silver nitrate the following action takes place:—

$$AgNO_3+HCl \rightarrow AgCl+HNO_3$$

Similarly, when sodium hydroxide is added to copper sulphate solution, we get this reaction—

$$2NaOH+CuSO_4 \rightarrow Cu(OH)_2+Na_2SO_4$$

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We can summarise as follows: Chemical actions taking place between acids, bases and salts *in water solution* consist of the exchange of radicles.

Let us now confine our attention to individual molecules. For chemical action to take place it is necessary for the molecules concerned to split up, and to re-arrange their atoms in a fresh way. In the first case considered above it would have seemed that the silver nitrate molecule might have split up in a number of different ways, but actually it split up in a definite way, and the re-arrangement effected was only as between radicles. There seems to be a tendency in the molecules of this class of substance to split up in this definite way. Chemical action between such molecules consists of two stages—first the splitting up of the molecule into its radicles, and then the joining up of radicles in fresh groups, if such joining up is possible.

Splitting up Radicles.

Considerations from several other points of view have led us to believe that the splitting up into the radicles has nothing whatever to do with the chemical action, and that it takes place when the molecules of the salt, the acid or the base are dissolved in water. A solution of silver nitrate is not considered to be a mixture of water and silver nitrate molecules, but a mixture of water, silver radicles, and nitrate radicles. When we add salt solution to this we are really adding a mixture of sodium radicles and chloride radicles, and then the chloride radicles seek out the silver radicles and join up with them to form a silver chloride molecule. Now silver chloride molecules are not soluble in water, and so when once they are formed they do not split up again into their radicles, but are *precipitated*.

Similarly, of course, the nitrate molecules come in contact with the sodium radicles, and even if momentarily they unite with them to form a sodium nitrate molecule, this immediately splits up again into the radicles, because sodium nitrate is soluble in water.

Mixing Salt Solutions.

What will be formed when two salt solutions are mixed is then a question of the solubility of all the molecules which can be formed. Those which are insoluble will be formed and precipitated. Thus, for example, if we mix together sulphuric acid and barium chloride solutions, we have a mixture of the following radicles—hydrogen (H), sulphate (SO_4), barium (Ba), chloride (Cl). These by union might form the following molecules: H_2SO_4, HCl, $BaSO_4$, $BaCl_2$.

Of these four molecules all are soluble in water except barium sulphate, which would, therefore, be precipitated. The table reproduced above gives roughly the solubilities of the more common salts, and can be used to find out what will happen when mixtures of solutions of salts, acids or bases are made.

Salts.	Solubility in water.
Chlorides	All soluble except $AgCl$, $HgCl$, $PbCl_2$, $CuCl$.
Sulphates	All soluble except $SrSO_4$, $BaSO_4$, $PbSO_4$.
Sulphites	All soluble except Na_2SO_3, K_2SO_3, $(NH_4)_2SO_3$.
Nitrates	All soluble.
Nitrites	All soluble.
Carbonates	All insoluble except Na_2CO_3, K_2CO_3 $(NH_4)_2CO_3$
Sulphides	All insoluble except Na_2S, K_2S, $(NH_4)_2S$.

At once arises a difficulty. According to this view a solution of common table-salt contains two radicles, and not molecules of the sodium chloride. The radicles consist of atoms of sodium and atoms of chlorine. Now, sodium we know as a metal which is lighter than water, has a violent action on it, and produces an evolution of the gas hydrogen. Chlorine we know as a green gas, which was used as a poison gas in the early days of the war. It has a choking effect on the throat. Yet none of these things do we see in a brine solution!

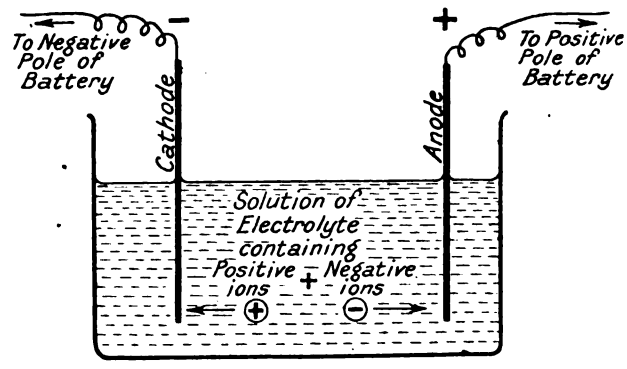
This difficulty has been explained by considerations arising from a very different field. From the earliest times it has appeared that somehow chemical action and electricity were connected. We can produce electricity as the result of chemical action taking place in a simple cell. In fact, the fundamental action in a big electricity works is the chemical action which goes on in the furnaces.

The explanation we are seeking, however, arose from consideration of the effect of electricity on solutions of salts, acids, and bases. Liquids as a rule are not good conductors of electricity. Many of them, in fact, are moderately good insulators, but if solutions of acids, bases or salts are used they are found to be almost as good conductors as metals. But, while the electric current is passing through these solutions, phenomena are observed which are usually summed up by the word *electrolysis*.

Experiment in Electrolysis.

A simple experiment to illustrate electrolysis can be carried out as illustrated in the diagram. The tank contains the liquid into which dip two electrodes connected with the positive and negative terminals of a battery—that is to say, one electrode is maintained at a positive potential and the other at a negative potential. Now, if the liquid is water then no current flows at all, the water being practically a non-conductor.

If we introduce a solution of a salt, an acid or a base in place of the water, we find that the circuit is completed, and what we call an electric current flows, just as if the whole circuit were a metal one. As far as the current is concerned there is no difference. If, however, we pay attention to the



Simple experimental apparatus which can be used to illustrate electrolysis.

(*Continued on page* 90.)

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The Television Society

Report of the Exhibition held during the March Meeting.

MEMBERS of the Television Society who were present at the Members' Night and Exhibition held at the Engineers' Club, Coventry Street, London, the form which the March meeting took, had the pleasure of meeting their President, Sir J. Ambrose Fleming, F.R.S., who had but recently returned from Egypt where he has been wintering.

Sir Ambrose arrived about 8.30 p.m., and welcoming him Dr. Tierney, the Chairman, said they could not let the opportunity pass without congratulating their President on the honour which His Majesty the King had been pleased to confer on him. (Applause.) He (Dr. Tierney) thought it was a compliment to the Television Society that the King had been pleased to confer the honour of knighthood on Dr. Fleming. (Hear, hear.)

The President's Speech.

Sir Ambrose, replying, said he was very pleased indeed to have the opportunity of meeting so many members of the Television Society, and expressing to them his grateful thanks for the kind congratulation which had been conveyed to him through their Secretary.

He understood that the honour which His Majesty had been pleased to confer on him was not in recognition of any work which he had done, but was a compliment to the whole of electrical science.

Scientific research to-day should be considered as a form of national service. As much, in fact, as political, social or philanthropic service.

With regard to scientific research, one could never tell what the result would be of any casual observation which was followed up with scientific knowledge. It was possible to quote dozens of instances of them.

There was the casual discovery of the effect of a piece of pitchblende on the photographic plate. This was accidentally left lying on a packet of plates, and when they were developed it was noticed that the plates had a black mark in the corner where the pitchblende had been lying. That was followed up by Monsieur and Madame Curie, and the result was to give us the element radium.

In the same way, a young chemist was instructed to make some experiments into the possibilities of a scientific production of quinine. He did not get this, but he got a black, dirty mess. Instead of throwing this down the sink, he started to work to find out what gave it that particular colour, and the result was the discovery which led to the aniline dye industry.

In the same way, he thought it would be agreed that there were wonderful potentialities in television.

He had been permitted, by the kindness of Mr. Baird, on many occasions to see his remarkable demonstrations, and as they knew the thing had now long passed the purely experimental stage, and he thought they would agree that the opportunity ought to be given to the public to see television on a large and extensive scale.

"I have seen some things only to-day," he said, "which show what an enormous addition to ordinary broadcasting the power of seeing the person speaking or singing is. It adds considerably to the pleasure of hearing the voice or music. You don't get the personality conveyed to you by speech alone as you do when you also see the living face. I think there is no scientific society in which the potentialities of discovery are so great as in the case of the Television Society."

Sir Ambrose thanked the Society again for their kind congratulations.

The Prime Minister's Letter.

Dr. Tierney said that before Professor Fleming visited the various exhibits they had a letter he would like to read. This had been received by Lord Angus Kennedy, their Vice-President, in reply to a question which he had addressed to the Prime Minister. The letter, which was dated from Downing Street, said:—

"MY LORD,

"The Prime Minister desires "me to refer to your letter of "the 23rd January, and to say "that he has made inquiries in "regard to the negotiations "between the Baird Television "Company, the British Broad-"casting Corporation, and the "General Post Office; and he "understands that since you "addressed your letter to him a "satisfactory arrangement has "been made between the Com-"pany and the British Broad-"casting Corporation."

"(Signed) H. G. VINCENT."

He was sure that all eagerly awaited the results of that arrangement. (Prolonged applause.)

Following this, Sir J. Ambrose Fleming, conducted by Dr. Tierney, visited the various exhibits.

Description of Exhibits.

The first exhibit visited was that of Mr. Llewelyn B. Atkinson, who was showing a collection of historical apparatus made in 1882 by himself when studying the question of tele-

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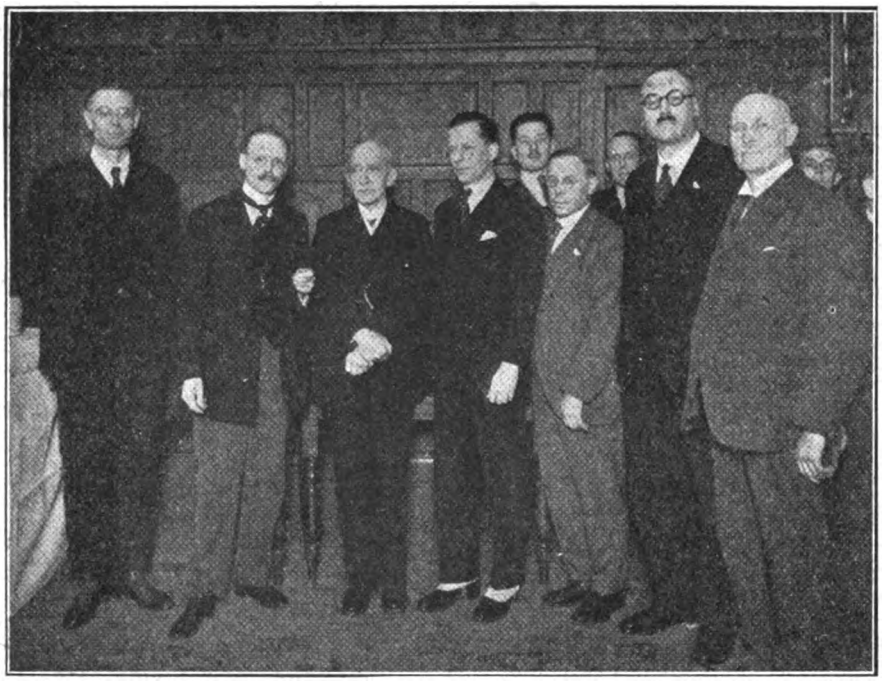


A distinguished group photographed at the March meeting. Left to right :—Lord Angus Kennedy (Vice-President), Dr. Tierney (Chairman), Sir Ambrose Fleming (President), N. B. Reynolds (Director, Television Press, Ltd.), J. J. Denton (Joint Hon. Sec.), Colonel Yelf (Member of Council), Llewelyn B. Atkinson (a prominent member and exhibitor).

vision. Describing his experiments, Mr. Atkinson said they were made when he was about eighteen years of age. His interest, he said, was drawn to this subject by an article in the *English Mechanic* for April 21st, 1882, written by a gentleman who signed himself "W. J.," and described an instrument which he called the "telectroscope."

The writer proposed using an instrument to scan the picture in which a single selenium cell was carried line by line across the picture, the current being varied by the cell to correspond with the light and dark points in the picture. The distribution of the light point was to be made by reflecting the light beam horizontally and vertically, as required, by a pair of glass prisms, while the light intensity was to be simultaneously varied by means of a pair of crossed Nicol prisms.

At the conclusion of the article the writer asked the opinion of readers, and in the issue of May, 1882, said Mr. Atkinson, a letter in reply written by himself appeared, in which he pointed out that the scheme would break down through the inertia of the Nicol prism arrangement. At that time he was a student at King's College, and turned his attention to the matter. As far as he knew that was the first time in which it was proposed to build up an image by analysing it and reintegrating it. He worked on that problem, and the first question that he dealt with was that of picking up the light from the image and breaking it up into a series of points. He proposed to do it by a mirror arrangement.

The models on the stand were some of those which he built at that time. One of them he found in a locked box in his father's house after his death.

Mr. Atkinson then took his models one by one and showed how they broke up the image. In most cases, for purposes of demonstration, some simple object served as an image. The various analysers employed lenses, prisms, mirrors, or a combination of all three to secure this scanning. One or two models for the purpose of reintegrating the image were also shown.

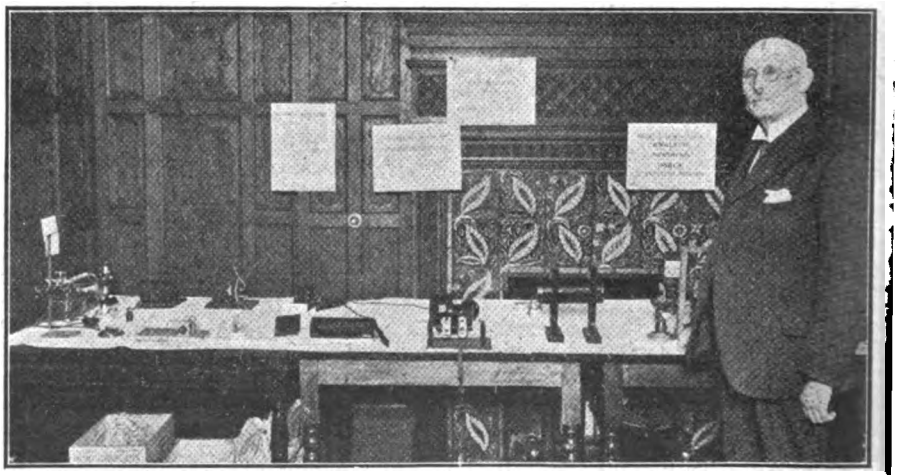
Sir Ambrose Fleming, when he inspected the exhibit, said he found it remarkably interesting. Such models should be in the South Kensington Museum as examples of the first attempts to solve the television problem.

The Chairman's Exhibit.

The Chairman of the Society, Dr. Tierney, had an exhibit showing molecular bombardment. He had brought a microscope and with monochromatic light and high magnification was showing volcanic dust, finely ground, in colloidal suspension. The tiny particles of dust, so small that they could barely be seen under the high magnification, were in a constant state of rotation as units, and at the same time were travelling about in the fluid in which they were suspended, yet they never collided with one another.

Introducing his exhibit, Dr. Tierney said that matter was regarded as being composed of a number of units, each in the form of a planetary system with a central sun and a number of planets moving around it. In the case of the atoms composing matter the central nucleus consisted of a number of positive charges, while around it revolved an equal number of negative charges. For instance, an atom of hydrogen had one free positive charge in the nucleus with one negatively charged planetary electron revolving around it.

Similarly, helium had two free



Mr. Llewelyn B. Atkinson's exhibit of early scanning and reintegrating apparatus.

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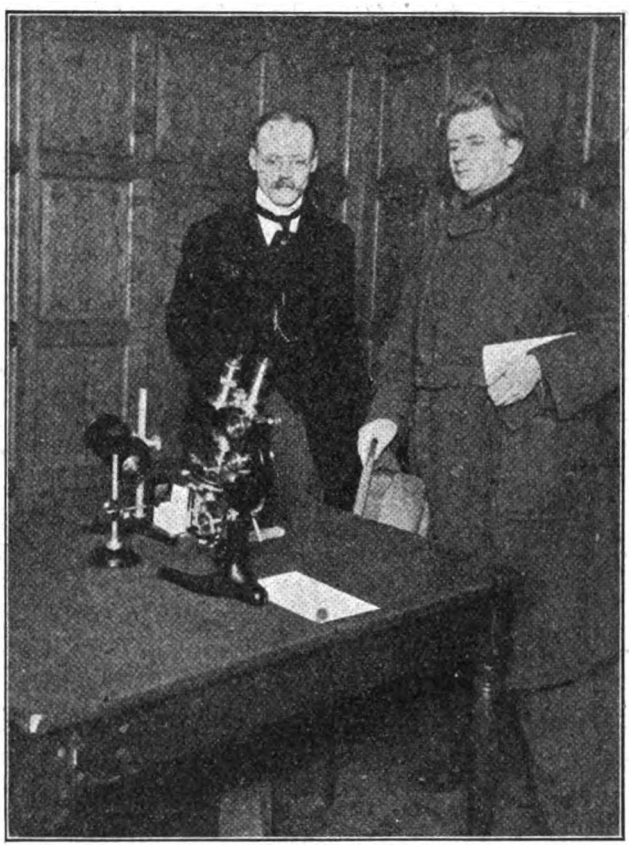
positive electrons in the nucleus with two negative electrons revolving round it, and so on throughout the whole of the elements. Gold had 79 positive charges in its nucleus, while mercury had 80. If in the case of mercury one of the free planetary electrons was able by any chance to find its way to the nucleus and counteract one of the free positive charges, then the balance of 80 would be reduced to 79. In other words, mercury would become gold. That was a thing scientific people always hoped to achieve, but although it might have been done in the laboratory, it had not yet been accomplished on a commercial scale. Nevertheless, the principle was obvious: To change mercury into gold one had only to alter the number of electrons.

In the microscope which he had brought down, they would see a small particle of volcanic ash collected from the deck of a ship lying close to Martinique during the volcanic eruption of 1902. The ash had been reduced to the finest possible dust in an agate mortar, and was now in colloidal suspension. They would see something of the movement of those particles, which although constantly in motion, kept a definite distance from one another. If they visualised the planetary system, and then the motion of that system as a whole around another body, they would have some idea of the motion of the particles of volcanic ash.

Even after all these years of quiescence that motion still took place.

Mr. H. S. Ryland (Fellow) exhibited a number of selenium cells and explained their manufacture and method of operation. To illustrate the effects of light on a cell he employed a very sensitive micro-ammeter and had a cell in circuit with a small voltage on it. In total darkness this cell permitted barely one micro-ampere to pass. In the normal light of the room (at the point where his table was situated it was rather dark) the current flowing went up to about 10 micro-amperes, while when a flash-lamp was directed on to the cell some hundreds of micro-amperes passed, the pointer going over to the limit of the scale on the meter. Among the cells which Mr. Ryland exhibited were the condenser type and the wire-wound type. One of these latter was in a bulb like a valve, but he explained that beyond keeping the cell clean, the placing of it in a vacuum was scarcely worth while.

Captain R. Wilson, who is a Fellow of the Society, had a very complete display of amateur television apparatus made by himself with which he was demonstrating the transmission and reception of simple shadowgraph images. His apparatus was generally on the lines of that described in the TELEVISION magazine some time ago, but had a number of refinements which he had introduced himself. In his receiver his amplifier was designed to function on a mains voltage of 200 to 220 volts, the push-pull system being employed. This had worked successfully for the reception of shadowgraphs and outside transmission. His synchronising arrangement was quite an original one and had proved both satisfactory and cheap.



Mr. J. L. Baird inspecting the Chairman's exhibit.

An ordinary motor rotated the disc which carried at a number of points on its circumference a series of studs. The studs passed between the jaws of a horse-shoe magnet energised by a four-volt battery and controlled by a small variable resistance. The motor speed was initially regulated by a variable resistance and the final speed adjustments were then made on the resistance controlling the magnet.

The transmitter followed the general lines laid down in the description given in TELEVISION. The selenium cell measured 1½ inches by 1 inch and was in circuit with 60 volts. Illumination was provided by a 1000-watt Osram lamp focussed through a projection lens. In the receiver the light source was a Raytheon neon lamp consisting of two parallel plates approximately 1 inch by 2½ inches and separated by about ⅛ inch. The lamp was struck by a separate voltage of 150. To secure the centring of the image the receiving motor was arranged to be rotated about its axis.

One of the most interesting exhibits was that brought by Mr. Colin P. Garside, a Student Member, who showed a home-made portable televisor. This little instrument was barely a foot square, and measured about 4 inches from front to back, the front panel carried a magnifying lens; on the side were mounted controls for synchronising and phasing.

The motor, 110-volt D.C. G.E.C., placed with its armature parallel to the plane of the disc in order to accommodate the phasing control gear, drove the disc through the phasing gear, through bevel gears at right angles, and by belt and pulleys on to the disc, the shaft of which carried several heavy wheels to compensate for any gear irregularities.

Phasing of the image—i.e., correction for difference of position of transmitter and receiver disc holes, was effected when synchronous speed had been reached, not by rotating the motor carcase, but by a form of epicyclic gear, whereby the gears carrying the drive could be rotated around the drivers when necessary.

Referring to Fig. 1, the pinion *F*,

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driven by the motor, transmits the drive through the gears *C* and *B* (on same shaft *G*) carried by the cast iron disc *A*, which can be rotated by means of the rubber friction wheel *D*. Thus by rotating the wheel *W* when the motor is running

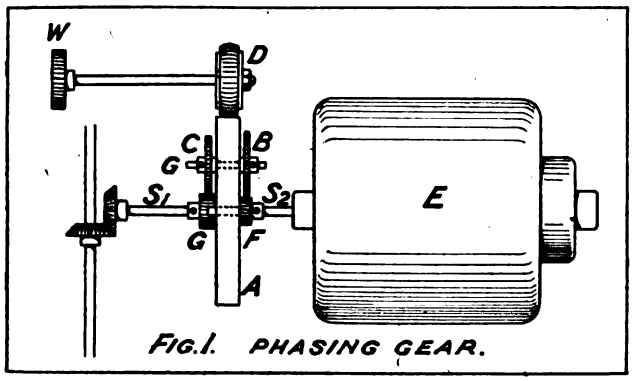

FIG. 1. PHASING GEAR.

the gears *C* and *B*, carrying the drive, will be rotated around the shafts S_1 and S_2, causing the ratio of the speeds of S_1 and S_2 to vary by an amount proportional to the speed with which *W* is rotated. The disc contains thirty holes, 1 mm. in diameter, and, using a Philips neon lamp, an image was successfully received from Capt. Wilson's transmitter.

Hon. Secretary's Exhibit.

Mr. J. J. Denton, one of the honorary secretaries, exhibited the operation of a dark ray based on the lecture experiments of Mr. Baird, who demonstrated the infra-red ray ringing bells, firing bombs, and actuating a burglar alarm in his lectures at Glasgow, Newcastle, and Dublin in 1927.

The ray was set up so that persons intercepting it operated an alarm, and members interested themselves in passing to and fro to start the alarm, and then resetting the apparatus.

Among other exhibits were a cathode ray tube which, owing to an unfortunate accident, could not be worked as it had broken down.

The General Electric Company showed a photo-electric cell working an "Automatic Counter." In this apparatus an ordinary beam of white light was used which, whenever it was interrupted, caused a neon lamp to light. The exhibit was explained by Mr. T. M. Lance, Associate of the Society.

Messrs. Philips Lamps, Limited, had a trade exhibit which included a number of two- and three-valve sets, accumulator chargers worked off alternating or direct current, a number of different types of loud-speakers and their latest type of gramophone pick-up. Several times during the evening this pick-up was demonstrated.

One of the first visitors to the exhibition was Mr. J. L. Baird, who complimented all concerned on the very interesting collection of apparatus they had been able to get together for the first Television Exhibition ever held.

* * *

Annual General Meeting.

Before the exhibition was opened, the Annual General Meeting of the Society was held, Dr. Tierney presiding. The first business was the proposal by the Chairman of a vote of congratulation to the President Professor J. A. Fleming on his knighthood. This was enthusiastically received, and the Secretary, Mr. Denton, then read the minutes of the previous annual meeting of March, 1928, which were duly confirmed and signed.

Following this, the first annual report of the Council was read by Mr. W. G. W. Mitchell, the Joint Secretary. This report covered the period September, 1927, to December, 1928, and stated that the council has been largely concerned with questions of organisation. The council had constantly had in mind the necessity of building up the organisation of the Society on a sound and lasting basis and to that end they had, from time to time, considered the different grades of membership within the Society and the qualifications which should be expected from applicants seeking membership.

It was their desire throughout to secure a high educational standard and this had resulted in the formation of two grades—namely, Fellows and Associates. Provision had also been made for the admission of those under the age of twenty-one as Student Members, the qualifications of such members being reviewed upon their attaining the age of twenty-one.

On September 30th, 1927, there were 48 Foundation Members on the roll; the membership of the Society on December 31st, 1928, was 115 Fellows, 92 Associates and 18 Student-Members, making a total membership of 225. Those figures indicated the membership for the period covered by the report, and only those members whose dues were fully paid up at December 31st last were included in the figures. There were, in addition to the 225 fully qualified members, over 500 additional names on the mailing lists of the Society, and the council learned with much satisfaction that a very large proportion of them had since become fully qualified members.

The council had decided that its policy of securing central control of the organisation through the executive council of the Society, with local centres in the provinces, was best suited to ensure unanimity of aim and purpose, and the council was able to report that the committees of the London and other local centres were now in process of formation. A form of procedure to be followed in forming a local centre and bye-laws governing the same was prepared and passed by the council and had already been circulated to those concerned.

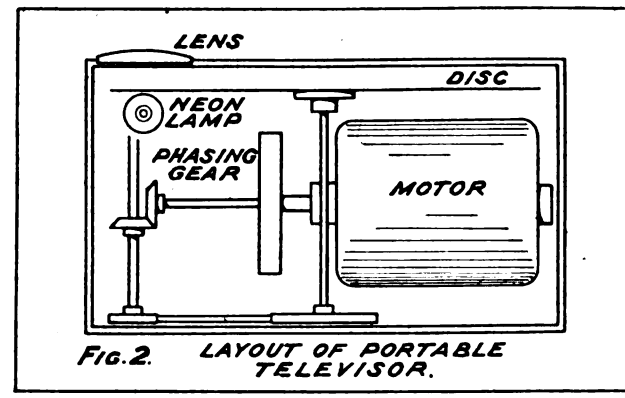

FIG. 2. LAYOUT OF PORTABLE TELEVISOR.

The council deeply regretted to have to record the death of the first President of the Society, the late Lord Haldane of Cloan, O.M., K.T., P.C., F.R.S., within a few months of his having accepted the presidency. The council was glad to

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record that Professor J. A. Fleming, M.A., D.Sc., F.R.S. (now Sir J. Ambrose Fleming) had accepted the office of President of the Society in succession to the late Lord Haldane. The council regretted to have to record in this, their first report, a further loss to the Society by the sudden death, on October 27th last, of Sir James Percy, D.L., J.P. His place as a vice-president had been filled by Lord Angus Kennedy.

The following lectures and meetings had taken place during the session :—

1928. APRIL 3RD.—Meeting to explain the constitution and outline the objects and work of the Society. Mr. T. W. Bartlett gave an outline of the Articles and Memorandum of Association. Mr. W. G. W. Mitchell, B.Sc., stated the aims of the Society and Mr. Alfred Dinsdale, A.M.I.R.E., dealt with the subject of papers for publication. The meeting concluded with a demonstration of the "Model Televisor" by Mr. F. J. Bingley, B.Sc.

1928. MAY 1ST.—Lecture on "Television," by Mr. J. L. Baird (with demonstration).

1928. JUNE 5TH.—Lecture on "Light-sensitive Cells," by Mr. W. G. W. Mitchell, B.Sc. (with Experiments).

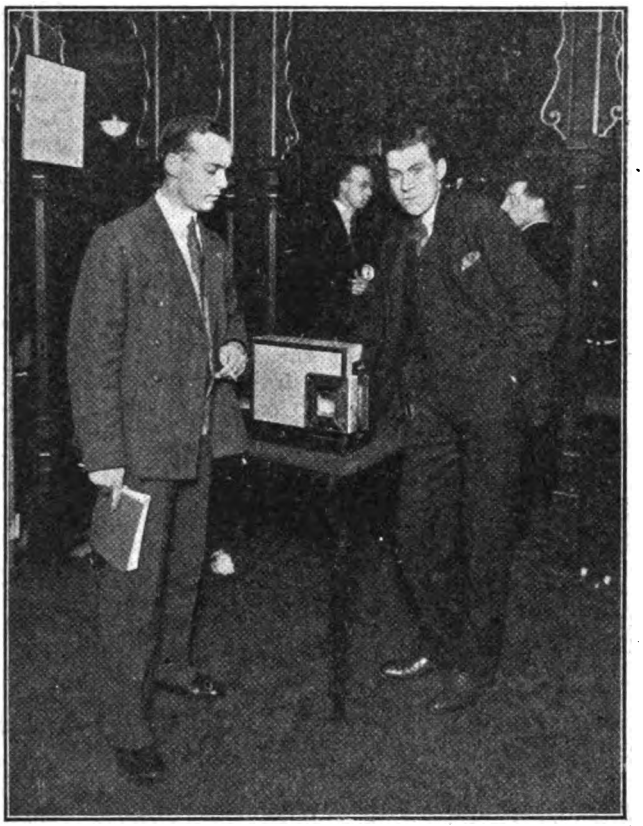
1928. NOVEMBER 6TH.—Lecture: "Science and Social Progress," by Major A. G. Church, D.S.O., M.C., B.Sc.

1928. DECEMBER 4TH.—Lecture: Professor F. J. Cheshire, C.B.E., A.R.C.S., F.I.P., on "Tuning-forks: How they talk and what they have to say" (with Experiments). Professor Cheshire's lecture was followed by a demonstration of television by wireless from the Baird Laboratories in Long Acre, W.C. 2, through the courtesy of the Directors of the Baird Television Development Co., Ltd.

All the above meetings were held at the Engineers' Club, Coventry Street, London, W. 1. All papers presented at the regular meetings, with reports of the discussions arising therefrom, had appeared in the official organ of the Society, TELEVISION, and had also been reprinted separately for circulation to the Fellows. The Council's thanks were due to the editor and publishers of TELEVISION for their courtesy.

In addition to the above lectures, the Council also wished to record that during the period covered by the report, many lectures had been delivered in London and the provinces by members of the Council and others.

The Council contemplated co-ordinating the work of interested members scattered throughout the provinces, and with that object in view had since circulated a "questionnaire" to ascertain the nature of the experiments undertaken by members of the Society. The replies had been very encouraging, as the following details showed:



Mr. Colin P. Garside (right) with his small portable televisor.

Of some 500 forms sent out, exactly 100 were returned to headquarters. The figures referred to the work of 34 Fellows, 55 Associates, and 11 Student Members (making 100 in all). Of the 100 replies, 63 members were actively engaged on experimental work in one or more branches of the subject. The actual numbers under the different headings were:

(*a*) Light-sensitive cells	35
(*b*) Exploring devices	19
(*c*) Amplifier design, etc.	31
(*d*) Image-forming devices	19
(*e*) Synchronising methods	21
(*f*) Transmission channels	8

Some eight members had experimented with picture-reception, and two or three appeared to be interested in phono-films, colour television, infra-red rays, etc. Twenty members had picked up British transmissions of vision signals, in most cases irregularly, and six members claimed to have picked up American broadcasts of television. Forty-six members expressed a wish to be put in touch with other members working on similar experiments.

The Council further contemplated compiling for the use of members a "bibliography" of current literature pertaining to all aspects of television, and the nucleus of a loan lantern slide collection had already been formed for the use of local centres.

The Council had not lost sight of its responsibility in the matter of securing to the experimenter and to the public, facilities for the reception of broadcast television, and to this end had been in correspondence with the Government department concerned.

In conclusion, the Council desired to place on record its appreciation and approval of the hearty co-operation it was receiving from interested workers throughout the world, notably in the British Dominions, America, France, Germany, Holland, Belgium, and elsewhere.

The Chairman, Dr. Tierney, then explained that there had not been time for the balance-sheet to be audited, and he did not, therefore, propose to place that before the meeting for adoption, but would ask Mr. Keay, the Treasurer, to speak to them.

Mr. Keay said that he thought the part of the balance-sheet which would be of the most interest to them was that dealing with the major portion of the expenditure, and that which gave them an indication of the receipts. They had to bear in mind that all the services of the Society were voluntary in character, and that a society of the type of which they were members could not possibly carry on with the limited income at its disposal, in the earlier stages at

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any rate, unless they depended on honorary services.

The balance in hand at the end of the year—and he would remind them that this figure had not yet been audited and checked—was £180. That, he thought, was satisfactory because it showed that they had spent just about half of the income received. But they must not forget, however, that there were certain expenditures which would be incurred at a not very distant future connected with the Articles of Association and Incorporation. It might be that before long they would have to acquire clerical services of various kinds, and they must also look forward to securing at some future date permanent premises for the use of the Society.

Mr. R. W. Corkling, proposing the adoption of the report, said as far as the financial statement went, it seemed to him an eminently satisfactory one, and he thought the Committee should be congratulated on having kept the expenses within very reasonable limits.—Mr. H. H. Hope seconded the adoption of the report, and it was carried unanimously.

Dr. Tierney said that as the balance-sheet had not been audited, he suggested that they should nominate auditors so that it might be formally and correctly presented at the next meeting. This proposition was accepted, and Colonel Yelf, as auditor on behalf of the Council, and Mr. R. R. Poole, as auditor on behalf of the members, were elected.

The Chairman pointed out that in the ordinary course of events the next business would be the election of officers and the members of council, but although it was included on the agenda, this time they could not elect officers and members of council because at the inaugural meeting those gentlemen had been elected to office for a period of two years, so that at the start-off the Society might have a reasonable continuity of policy.

Their next business was to consider the programme for the remainder of the session.

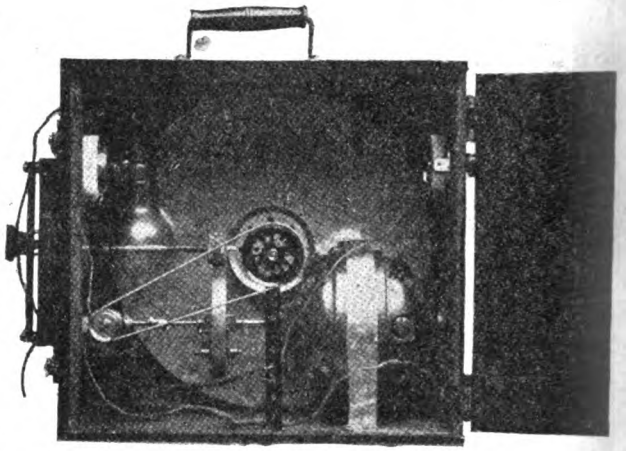
Dr. Tierney said the members might like to consider the question of the date of the next meeting. The first Tuesday in April might be a very inconvenient one for many of them. On the other hand, quite a number of country members might be coming to visit London about that date and would be able to attend the meeting, and it rested with them whether they held their meeting on that date or a later one.

Colonel Yelf, one of the founder members present, suggested the second week in April (April 9th) and this date was seconded and carried unanimously.

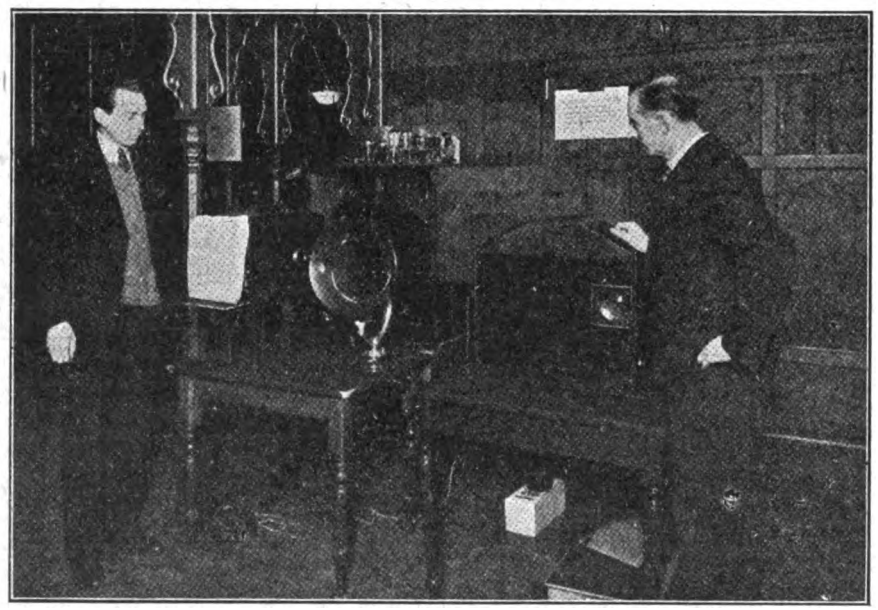
Dr. Tierney said that television was an entirely new subject and there were not the number of workers in so new a science as there would undoubtedly be later on, but that it might not be at all a bad plan to have a meeting or meetings set apart for a series of short addresses, when the workers could get together and deal in quite a brief way, talking perhaps for ten or fifteen minutes each on the problems they were trying to solve. There must be many who would hesitate about talking for a whole evening, but who would probably be very glad to have the opportunity of reading a short paper and getting the opinion of other members on such points as interested them.

They might also be glad of such a chance to demonstrate a piece of apparatus and take part in the discussion on it. He thought that an evening of that kind at the present stage in the Society's history might be very valuable. This suggestion was welcomed by one member present who confessed that he would be terrified if asked to occupy a whole evening with a paper, but the opportunity of giving a short paper on his own particular difficulties, and hearing similar papers by other members, would be exceedingly interesting.

This suggestion was unanimously adopted by the meeting, and the Chairman then read a number of letters from members who were



Interior view of Mr. Colin P. Garside's portable televisor.



Captain R. Wilson (left) with his shadowgraph transmitter and receiver.

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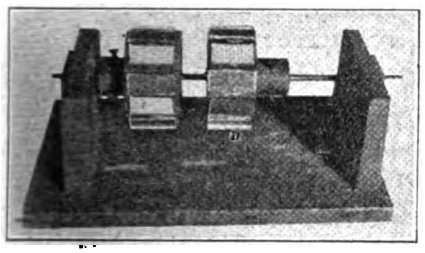
unable to attend. One of these letters was received from a Fellow in Moscow who wished the Society success and hoped that the television problem would soon be solved so that he might have a receiver installed and see what the Television



Mr. Atkinson's original image-scanning mechanism, consisting of revolving mirror wheels.

Society were doing in London at their meetings. He mentioned that he had carried on experimental work in connection with picture transmission between Moscow and Berlin.

The Chairman said it was very nice to learn that they were being thought of in Moscow. At the moment few appreciated the very difficult conditions under which scientific work in that city was being carried on, and he suggested that the Secretary should write to send the Society's greetings to this worker in Moscow. This suggestion was unanimously accepted.

The formal business of the meeting being concluded, Dr. Tierney asked if any members had any questions they would like to ask. The first question was asked by a member who wanted to know if any information could be given about the transmissions he understood were being carried out by the B.B.C.

Dr. Tierney replied that he understood that the tests referred to by the member were essentially of a confidential nature and that no statements could be made concerning them. He believed it was true they were going on, but as to how far they had gone there was no further information.

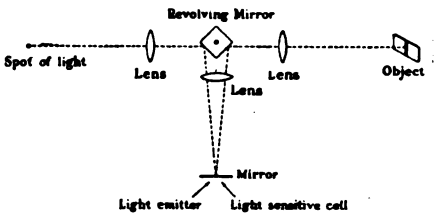
Another member asked if any information could be given concerning the reported amalgamation of the Baird Company with the Fultograph Company.

Dr. Tierney replied that that was a matter with which the Society, as such, was not concerned. It was a company business and the inquiry should be addressed to either the Baird Company or the Fultograph Company.

Another member asked what steps were being taken to provide the Society with a television receiver.

The answer to that, said Dr. Tierney, was a simple one. Until transmissions were taking place a receiver would be of little use. He believed that when transmissions did take place there would be a queue lining up to purchase receivers, and he suggested that as transmissions would soon be taking place members should get acquainted with the construction of the apparatus. Transmissions would certainly not be deferred indefinitely; there was too much opinion now as to the satisfactory nature of transmissions for the present state of affairs to exist much longer.

The member who had raised the question pointed out that it was very difficult for obscure members to find out details of construction, and this information could be easily



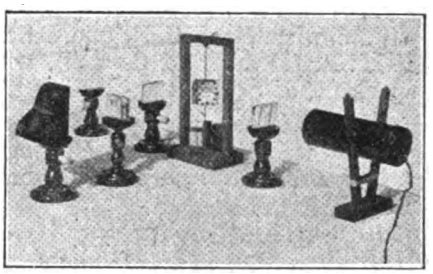
Diagrammatic representation of Mr. Atkinson's early scheme.

gathered if they could see the apparatus. As an indication of what he wanted he referred to the wireless magazines which weekly produced half a dozen different types of receivers. As far as his knowledge went only one description had been published in the magazine, and he thought something should be done to provide them with further sets of working designs so that they could get on with constructional work. He thought the Society might write to the editor of the magazine, requesting that more constructional articles should appear.

Dr. Tierney, answering his further question, said he would be sorry to embarrass the editor and manager of the magazine, but he thought that if the member would write to the editor of TELEVISION and ask for more constructional articles it might have a good effect. It would also help the editor if those members who had been working on any particular problem would write and give him a description of their work so that it could be published.* As they all knew, there had already been one description of apparatus published, and he thought if the members who had built that apparatus would describe their results it would be helpful to others. Wherever one got half a dozen workers in a particular branch, their results were never identical, and articles written by such workers could be of great help if communicated to the Journal, and to other workers, and they would in any case materially assist development.

A suggestion that the Secretary should write to the editor of the magazine asking for the publication of more constructional articles was unanimously adopted.

When this motion was passed, Dr. Tierney pointed out that the editor would reply that the question had been considered, but that he was awaiting certain details from the Baird Company. It was perfectly obvious that the problem was a little difficult at the present time, said Dr. Tierney, until the question of transmissions was definitely settled. The question of reception was a simple matter. The Council had not lost sight of their responsibility to the public to secure facilities for television reception. The question of transmission had been held up for the past twelve months. It was now reasonably within sight, and he thought that once transmission was definitely established there would be no need to hold back technical details as to the construction of the receiver. "It is just a question now of delicate negotiations which are going on, and



Photograph of the apparatus shown in Fig. 3, which was devised by Mr. Atkinson in 1882.

as I have already indicated, we are getting very near to the date when transmissions will become a regular thing."

A very cordial vote of thanks to

*We welcome this suggestion.—ED.

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the Council, Chairman and Officers for their very valuable services during the past year was carried with applause. Dr. Tierney replied in appropriate terms on behalf of his colleagues.

Secretaries' Announcements.

The Annual General Meeting of the Television Society marked the close of the first year of the Society's work, and all members present were congratulatory on the growth and conscious effort of the whole of this well-timed organisation. The Membership is close on 500 strong, the majority being Fellows having academic or other special qualifications, and over 500 other indexed names have been regularly notified of the Society's meetings, as a result of applications or requests.

The time has now come to weed out this latter number so that the Secretariat may devote full attention to its fully paid Membership. Interested persons should apply for application forms of Membership to the Secretaries, Television Society, 95, Belgrave-road, S.W.1.

The Treasurer calls attention to the fact that subscriptions for this year are now due, and the Secretaries have been instructed to have engraved a more imposing Certificate for the use of Members.

The Proceedings for the year are now in hand and are being posted to all Fellows.

A further supply of Badges is now available for Members at cost price of 1s.

The next meeting will be held at the Engineers' Club, Coventry-street, W.1, on Tuesday, April 9th, at 8 p.m., when Mr. J. C. Rennie, B.Sc., M.I.E.E. (Member of Council), will speak on "Some Notes on Exploring."

Visitors (authorised by a Member) will be welcomed at this Meeting; they are asked to sign the "Visitors' Book."

J. DENTON, A.M.I.E.E.
W. G. W. MITCHELL, B.Sc.
Joint Hon. Secretaries.

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The Story of Chemistry.

(*Concluded from page* 82.)

liquid portion of the circuit we see that further phenomena are taking place. It will help if we take a concrete case. We will suppose that we make the solution in the tank a solution of copper chloride.

Now, while the current is passing, we shall see that from the positive electrode bubbles of a gas are coming off. They will appear on the electrode, grow, break off, and by a suitable arrangement of the apparatus could be collected. They would be found to form a green gas which we should have no difficulty in identifying as chlorine. Then on the negative electrode we should find that metallic copper was being deposited. This production of chlorine and copper would continue as long as the current flowed, and as long as any of the copper chloride remained in solution.

Electrolytic Action.

Here then we see, by the influence of the electric current, the copper chloride which we put in the solution is being removed. Copper chloride being a salt, we suppose that when it was dissolved it split up into its radicles—copper and chloride radicles. We can represent this thus—

$$CuCl_2 \rightarrow (Cu) + 2(Cl)$$

Now the passage of electricity through the system has resulted in the sorting out of these radicles. The copper appeared on one electrode and the chloride at the other. The explanation is more or less obvious. If we suppose that the copper radicles were positively charged, then they would be attracted by the negative electrode, and move through the solution towards it, and if the chloride radicles were negatively charged, then they would move towards the positive electrode.

Ions.

Thus, from a consideration of the passage of electricity through solution of acids, bases, and salts, we come to the conclusion that, when these substances are dissolved in water, they split up into two parts which bear electric charges. One part is negatively charged and the other positively charged, and as the solution is electrically neutral the charges must be equal and opposite. Such charged particles are called IONS, and must occupy our attention in the next article.

What "Nature" Thinks

We reproduce below a brief review of the present state of development of television which appeared in the March 16th issue of "Nature," the leading scientific journal in this country, and, in fact, in the world.

The inauguration of a television broadcasting service in Great Britain is at present being considered by the Post Office officials. Great progress has recently been made at the Baird laboratories and very satisfactory demonstrations of land line transmissions have been given on a "televisor." It is quite easy to "tune in" the picture by one control and "frame" it correctly by the other control. The pictures are still somewhat limited in size, but excellent "head and shoulders" reproductions are given, and in conjunction with a loud speaker give a very interesting performance. Considerable detail is given in the picture—the time, for example, on the performer's watch can be easily read. A high tension pressure of 350 volts is required for the home televisor, but if an alternating current lighting supply is available, this can be readily obtained by an "eliminator." At present the sets are designed for a fixed wavelength of 200 metres (1,500 kilocycles). It is, perhaps, too early to say what is the narrowest band of frequencies that is necessary to transmit a sufficiently satisfactory picture. In the event of the establishment of a television broadcasting service, it would be advisable to have as narrow a band as possible so as to avoid interference with the ordinary broadcasting and other services. Everything depends on how much flicker and lack of detail can be permitted without appreciably detracting from the pleasure of the "looker-on." Television for the theatre seems to be an easier problem than television for the home. As this would be worked throughout by experts, the large performance factor of safety required for home sets would be unnecessary.

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The Wider Outlook

By NOËL SWANNE

YOU see I was right. I always am. It is a great pity that people do not recognise this fact. I said that, once my letter reached the B.B.C., all would be well, and now we are gathering the dear old bay-leaves—or should it be bay horses? Anyhow . . . I mean to say . . . if it is a case where a little tact and a few brains . . .

* * *

Marjorie has interrupted to remark that she hopes I realise that when the world in general is invited to participate in television there will be a huge crowd of very ignorant people, who will want to know all about everything. No longer will it be the privilege of the few brainy people like herself. I said "Of course!"

I gather that she considers I should drop my instructive and lightly amusing tone, and get down to brass tacks and tell the world. "Oyez! Oyez! Be it known by these presents . . ."

"Thank you," said Marjorie.

"Whaffor?" I asked.

"Presents, stupid! I wanted a new hat," she replied.

I tried to ignore this.

"You dear people," I continued, "sitting round the fire . . ."

"Pity us poor children in the mud and mire," chanted Marjorie.

I tried to ignore this, too.

". . . I want you to realise that scientists have now placed in your hands the greatest instrument for the progress of nations, since the day when an apple batted Newton in the left eye."

* * *

"What has Newton to do with it?" asked Marjorie.

"Without gravitation there would be no television . . ."

"Why?" said Marjorie.

"Well, for one thing, without gravitation, you would fly off at a tangent. Fly off into outer space . . . and I should be left in peace to finish this most important article," I answered.

For a time I wrote in silence, thus:—

"Things which have been in the past but sounds for you, will now be clothed with the flesh and blood of reality. No longer will you hear of the intestines of the lower order of arthropoda, but you will *see* them. It will make you feel sicker than you do now. You see how we progress.

"Then events which were to you a pageant will take on their true form. In all the colours of the rainbow . . ."

Marjorie broke in—"Where have you got to now?" she said.

I sighed.

"I'm awfully fascinated," she continued. "The idea of flying on that tangent thing into outer space is thrilling. Will television really do that?"

She is right, dead right. There is a terrible mass of ignorance about.

"My dear child," I said, "television is not a tangent. I mean it is a discovery which will enable you to see by wireless. In the ether . . . in the ether . . . which pervades space . . . the electrons will set up disturbances. They radiate . . . outwards . . . and our set in yonder corner will take them in . . . inwards. On the screen you will see what it is that is making the electrons disturbed. . . . It will all be reproduced for your benefit. The world in time will be brought into our own room."

I paused to note the thoughtful attention which I was receiving.

"It is all frightfully difficult," I explained. "The electrons are difficult things to manage. They rush about so. They need control . . . but you need not worry, because all you will have to do is to turn the thing on. If anything goes wrong I shall be about."

"That will save *my* 'phoning the shop, won't it?" commented Marjorie.

I didn't like the emphasis she put on the "my," but one has to realise

(*Continued on page* 94.)

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Magnifying Powers of Telescopes—
The "pupils" of an Optical Instrument

Part IX

By Professor CHESHIRE, C.B.E., A.R.C.S., F.I.P.

AT the end of our last article, in the March issue of TELEVISION, it was shown that the magnifying power of a telescope is equal to the ratio of the focal lengths of the object-glass (O.G.) and the ocular (Oc.). In other words, if a distant object subtends an angle α in free vision, it will, when seen through a telescope of magnifying power M, be seen under an angle β, such that

$$\beta = M\alpha = \alpha f_1/f_2 \quad \ldots (1)$$

where f_1 and f_2 are the focal lengths of the O.G. and Oc. respectively. The moon, for example, which subtends an angle of half a degree in free vision, when seen with a telescope magnifying fifty times subtends an angle of 25 degrees.

It was shown further, in the article referred to, that the magnifying power is also equal to the diameter of a bundle of rays entering the telescope from a distant axial object-point, divided by the diameter of the corresponding emergent bundle of rays. This fact enables us to determine the M.P. in a simple way without dismantling the telescope. The method appeals to every user of a telescope or field-glass, since the only essential piece of apparatus for carrying it out is a foot rule.

Finding the M.P. of a Telescope with a Foot Rule.

First, focus the telescope, whether of the astronomical, terrestrial, or binocular (prismatic) type, upon a distant object, to ensure that parallel incident rays emerge as parallel rays. Then (1) measure the *operative* diameter of the O.G.; and (2) the diameter of the eye-ring or Ramsden circle, that bright and sharply-defined disc of light which is seen just in front of the eyepiece, or ocular, when a telescope is held at arm's length and pointed to the sky. Dividing the measure of the first diameter by that of the second we get the magnifying power required.

Example.—A pair of prismatic binoculars is fitted with 30 mm. O.G.'s. The eye-rings were found to have a diameter of 5 mm. so that the M.P. is equal to $30/5 = 6$ times.

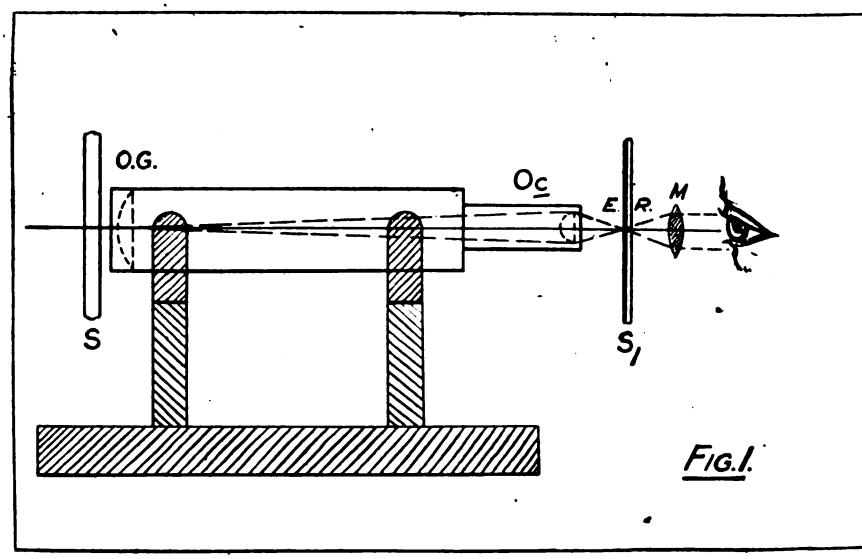
The famous Yerkes telescope, at Chicago, has a clear opening of 40 inches and a focal length of 62 feet. Find (1) the focal length of the ocular giving a M.P. of 1500; and (2) the diameter of the eye-ring in this case. Here the focal length of the ocular must be made equal to $62 \times 12/1500$ inches $= 1/2$ in. (approx.) and the diameter of the eye-ring then equals $40/1500 = .0027$ inch.

A word of caution is necessary here. We have spoken of the *operative* diameter of the O.G., and generally, in a first-class instrument, this operative, or effective diameter is equal to that of the exposed O.G., as seen from the outside. In telescopes of doubtful character, however, particularly in those antiquated relics of which the sea-side boatman is so proud, it sometimes happens that the O.G. will not work satisfactorily at its full aperture as thus determined. A stop is then fitted internally, usually in the erector, to cut down the effective aperture of the O.G. to that at which it will work satisfactorily.*

Of course, this is done at the expense of the light-collecting power of the telescope. In this case the division of the diameter of the exposed O.G. by the diameter of the eye-ring gives too high a value for the M.P.

The true value can be found in all cases by proceeding as follows: The telescope, adjusted for distant vision, is mounted in a horizontal position in a pair of V-supports on an optical bench, as in Fig. 1. A transparent scale S is fixed in front of the O.G. and an image of it projected in the way already described, into the plane of the eye-ring (E.R.). The total length of the scale S which can be

* Such a telescope is a fraud because it is larger and therefore more costly than it should be for its optical power.



Finding the Magnifying Power of a Telescope.

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read off along the vertical diameter of the eye-ring is the operative or effective diameter of the O.G.

Should an internal stop cut down the aperture of the O.G., then the

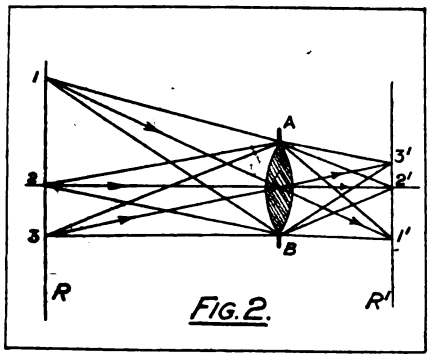

FIG. 2.

Limitation of Imaging Cones of Rays.

length of the scale S projected will be less than the diameter of the O.G. as measured externally. The scale S is then placed in the plane of the eye-ring and the latter read off with the assistance of the magnifying lens M. The first measurement divided by the second gives the desired M.P.

If a transparent scale is not available, two parallel straight lines should be drawn in ink on a piece of thin transparent paper, at a distance apart just a little less than the apparent clear aperture of the O.G. This should be stuck with wax in front of the O.G. and the eye-ring then examined.

If the two lines can be seen simultaneously, well within the eye-ring, draw another pair slightly farther apart. Do this until the projected lines exactly span the eye-ring. Finally measure the distance apart of the lines, which is the effective diameter of the O.G. The eye-ring may be measured with an ordinary opaque scale, so that it presents no difficulties.

The Pupils of an Optical System.

In free vision the total amount of light which enters the eye for imaging purposes, from an object-point, such as a star, depends upon the size or diameter of the pupillary opening in the iris. This may be as great as 8 mm. (1/3 of an inch) in star-gazing on a dark night; or as little as 2 mm. in bright sunlight.

Similarly in the case of the photographic lens. The amount of light which passes through it from an axial point of the object for picture-forming purposes depends, not only upon the light emitted or reflected by that point, but also upon the size of the aperture in the iris diaphragm.

In Fig. 2 the simple case is shown in which a single thin lens is used to project upon a screen R' images 1', 2', 3', of three object-points 1, 2, and 3 occurring in a plane R. In this case the opening in the lens mount not only acts as an iris, but also as a common base for the imaging cones of rays entering and passing through the lens. The circular aperture, with its diameter AB, is the common base of the ray-cone $A3B$ on the object side and the corresponding ray-cone $A3'B$ on the image side. The greater these cones the greater the amount of light passed, the greater the rapidity of the lens, but unfortunately the less the focal depth, as we shall see later.

Fig. 3 shows, diagrammatically, a simple telescope of the erecting or terrestrial type in which a pair of parallel rays, drawn in full lines, are first brought to a focus in the plane P^1, by the O.G., and then diverging, pass through the two lenses of the erecting system to be again brought to a focus in the plane P^2, the focal plane of the Oc. An inverted image of a distant object is thus formed in the plane P^1. An inverted image of

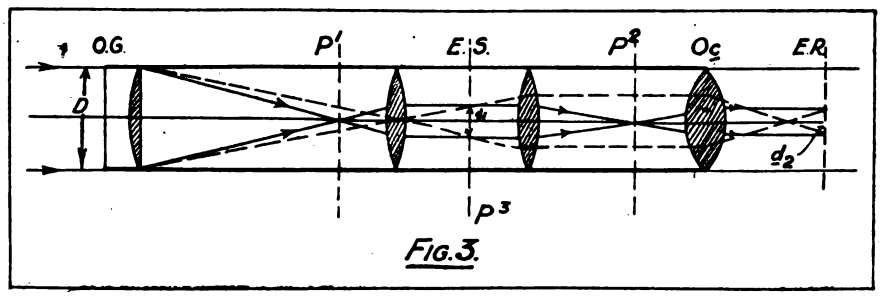

FIG. 3.

Optical Diagram of Erecting Telescope.

this image—that is an upright image of the object—is then projected by the erecting system into the plane P^2, where it is finally seen with the aid of the single lens Oc., acting as a magnifier.

With the telescope adjusted as shown, we will now consider the circular mount of the O.G., as an object and find out where its images fall. For this purpose a pair of dotted rays are shown starting from the top and bottom of the O.G. mount. These rays have been drawn to pass through the centre of the first lens of the erector without being refracted, therefore, but passing on they are refracted by the second lens of the erector, and the ocular, to meet again in a point outside the telescope as shown.

Now considering both the rays shown in full lines and also those shown in dotted lines, we see that an image of the O.G. mount with diameter D is projected by the first lens of the erector into the plane P^3, with a diameter d_1. But this image d_1 is again projected by the second lens of the erector, and the ocular, into the plane E.R. of the eye-ring or Ramsden circle, to form an image of the O.G. opening with a diameter d_2, and, as already proved, the M.P. of the telescope is equal to D/d_2. A stop is usually placed in the plane P^3, with an opening of diameter d_1, equal to the length of the projected diameter of the O.G. mount.

With a smaller opening than d_1, the effective diameter of the O.G. is lessened, because a peripheral annulus of the O.G. no longer transmits imaging rays to the eye. The erector stop, in these circumstances, becomes the iris of the telescope.

Generally, then, in well-designed erecting telescopes, the total amount of light collected for imaging purposes is determined by the metal mount of the O.G. All the rays which pass through this ultimately pass through the eye-ring and are available for imaging purposes, so that this mount is the iris of the telescope.

Entrance- and Exit-Pupils of Optical Systems.

We are indebted to the late Professor Abbe, of Jena, for the modern conception and use of the "pupils" of an optical system for the purpose of studying aperture problems. Apertures, or stops, function in the main for three purposes, namely, the limitation of (1) the amount of light which is collected and utilised for image formation; (2) focal depth, and (3) the angular field of

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view. For the present we will confine our attention to the first of these.

Let the angle between two rectangular mirrors A and B, Fig. 4, be divided by a plate in which a circular

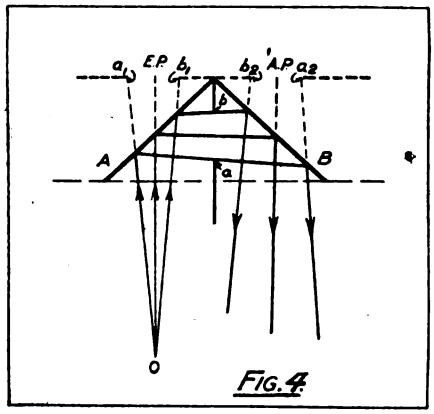

FIG. 4

The Pupils of a Reflecting System of two Rectangular Mirrors.

aperture of diameter $a-b$ is cut. For an axial-object point O, the aperture $a-b$, is the iris. An image of this aperture is formed at E.P. by the mirror A, and at A.P. by the mirror B, so that a ray drawn from O to any point in the image E.P. will be reflected by A, through a similarly situated point in the iris.

This ray also, after reflection by the mirror B, will finally emerge as from a similarly situated point in the image A.P. It is evident that any ray whatever drawn from O, to a point in the image E.P., must finally, after being twice reflected, emerge as from a corresponding point in the image A.P.

Abbe defined as the *entrance pupil* (*Eintrittspupille*) the image of the iris produced by that part of an optical system—the mirror A in this case—which occurs between the iris and the object; and as the *exit pupil* (*Austrittspupille*) the image of the iris produced by that part of an optical system—the mirror B in this case—which occurs between the iris and the final projected image.

In Fig. 4 the ray stating from O, and passing after reflection through the point a, in the iris, is directed towards a_1, the image of a, before reflection by the mirror A.

After reflection by B the ray proceeds as from the point a_2, which again is the image of a. Similarly with the ray passing through the point b in the iris.

In Fig. 5 a lens A, is shown fitted with a stop behind it. To an eye at B the stop is not seen directly, but only its image as shown in dotted lines. For rays passing through A from right to left from an axial object-point not shown the stop itself acts as the iris, and the image of this iris formed by that part of the system which occurs between the iris and the object is, by our definition above, the entrance-pupil E.P. The iris in this case acts also as the exit-pupil, because no part of the optical system occurs between it and the final image.

In Fig. 6 is shown a simple type of a doublet photo-lens with symmetrically fitted iris diaphragm. The image E.P., of the iris, I., in the lens A is the entrance-pupil for light passing from left to right, whilst the image A.P. of I., in the lens B, is the exit-pupil.

The entrance and exit-pupils are thus the common bases of the imaging cones of rays in the object- and image-spaces respectively.

In Fig. 2 the mount of the lens

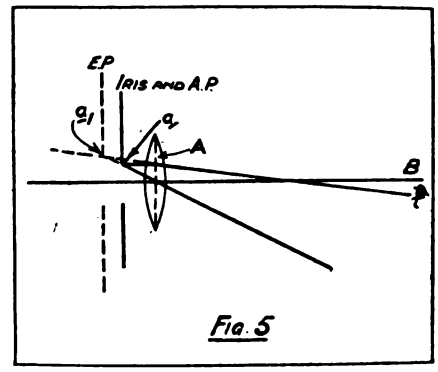

FIG. 5

Image of Stop in Lens.

functions as the iris, entrance-pupil, and exit-pupil. It limits the size of the imaging cones of rays, both on the object and image sides, and serves at the same time as a common base for these cones.

Fig. 3 also serves as an interesting example of the disposition of iris and pupils. Upon the supposition that the aperture or stop d_1 is large enough to pass all the rays collected by the O.G., from an axial object-point, the mount of the latter acts as the iris, and the image of this—the eye-ring, E.R.—projected by the erector and ocular is the exit-pupil.

When the stop d_1 is small enough it acts as the iris, E.R. is still the exit-pupil, but the entrance-pupil is now the image of d_1, projected by the first lens of the erector and the O.G. Since, however, the O.G. is in the plane of the image projected by the first lens of the erector, it (the image) is not displaced by the O.G.

The E.P., therefore, occurs in the place of the O.G. mount, but is smaller in diameter.

In our next article we shall see how beautifully and simply the pupils of a system enable us to deal with the important subject of focal depth.

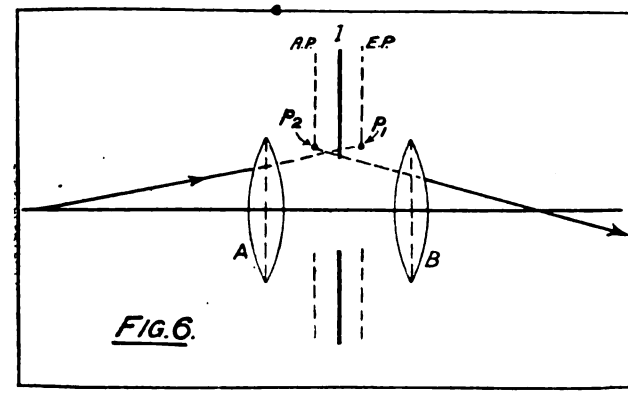

FIG. 6.

Iris and Pupils of Photographic Lens.

The Wider Outlook.

(*Concluded from page* 91.)

the limitations of the feminine mind. I turned back to my writing.

"What it will mean, few of us can imagine. Our narrow outlook will broaden. At first, little studio scenes, then experimental work in the open, then the flinging of the tentacles in an ever-widening circle. The home life of the Russian moujik, as he sits watching his grandfather die in tears. The sparkling grandeur of the Eastern Potentate taking farewell of his favourite elephant. The glory of an English spring, with the sight of the driving sleet. When Eliza Brown, the famous Italian soprano, fills Covent Garden with a top B-flat, we shall see her palpitating seventeen stones shaking the stage. There are no limits to which we may not rise."

* * *

"I don't suppose we shall see any of it," said Marjorie.

"Why not," I queried indignantly.

"Probably Jix will decide it is not good for us, and make it illegal after 7 a.m. in the morning."

Well . . . !

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A Message from Mars

By DEREK IRONSIDE

A FIZZLING arc-light threw an unsteady glare upon the group of men who stood around the mouth of the shaft, the circular concrete walls of which vanished in shadow underground. Suspended above the shaft from a power-crane hung a huge steel projectile that was presently to be lowered into its depths.

Bullivant turned a fierce, bearded face towards his friend. "In ten minutes, Arnold, it'll be over, one way or the other. At the bottom of that 200 ft. shaft there are packed three tons of merinite, the most powerful explosive known to modern science. At 10.13 I shall make electrical contact, and if my calculations are correct, as they must be, that projectile with my six men and myself inside it will hurtle out into space towards the planet Mars.

"We shall leave the shaft at a speed approximating two miles a second, and will probably reach the limit of the terrestrial atmosphere within a minute. Once out in space, I'm relying on my rocket-discharge apparatus to increase my speed to 80,000 miles an hour. By the twenty-first day after leaving the earth we shall be falling like a meteorite on to the surface of Mars, using our retarding rockets to break the force of impact."

A Colossal Scoop.

Arnold, the night editor of the *Argus*, shook the scientist's hand warmly. "I wish you the best of luck, Bullivant. And many thanks for getting me down here. This means a colossal scoop for my paper, you know."

As Bullivant and his companions vanished out of sight into that grim projectile, Arnold had a queer sense of the uncanniness of the whole affair. But for Bullivant's infectious enthusiasm he would have regarded this attempt to cross interplanetary space as absolutely crazy. And now, as the ugly steel bullet, 50 ft. long and 14 ft. in diameter, sank out of sight into the bowels of the earth, he had a presentiment that never would he see Bullivant again.

"Everybody to the far side of the meadow," came the stentorian roar of the young scientist in charge of the preparations above ground. Arnold and his chief sub-editor obeyed promptly along with the other privileged spectators, and waited expectantly.

"You're an old friend of Bullivant's, aren't you, sir?" questioned the sub-editor curiously. "He's certainly let you on to something good. We seem to be the only press representatives here."

"Yes, I was his fag at Charterhouse. He was a fearful bully, but nevertheless he seemed to take a liking to me. Also, I've been able to give him a little useful publicity from time to time, and despite his other faults he's certainly never ungrateful. But he's a very difficult man to get on with, and judging from the look of his companions he seems to have picked up six of the toughest cases one could possibly find between Stepney and the Old Kent Road. If the Martians get on the wrong side of Bullivant and Co. I shall feel sorry for them. The Spaniards amongst the Mexican Indians will be a mothers' meeting in comparison.

Suspended above the shaft from a power-crane hung a huge steel projectile that was presently to be lowered into its depths.

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" But will they ever get to Mars ? More likely to come smashing back to the earth after a few miles, even if their shaft doesn't burst when the explosive charge is fired."

Well Equipped.

" Who knows ? " answered Arnold gravely. " Anyhow, Bullivant is going well prepared. There's every conceivable sort of equipment packed away in the store-rooms of that projectile, from television and wireless transmitters to machine-guns and sewing-machines. Bullivant has fitted up a special television receiver personally in the top story of the *Argus* building, you know, and he's conceded us, half playfully, half seriously, sole rights to receive Martian television. Now hold on, it's almost thirteen minutes past. They've cleared away the crane."

A few seconds elapsed. Then from the centre of the huge meadow where they stood there gushed out a vertical pillar of flame reaching to the very dome of the heavens, and stabbing the night sky like a gigantic blood-red sword. Almost instantaneously it was followed by a shattering explosion that shook South London to its very foundations. Bullivant's projectile had been launched.

* * *

" It's a month since old Bullivant went off in his crazy rocket," remarked the chief sub-editor as he brought a fresh proof into the night editor's room. " There's been never a sign of him since."

" Not a sign," agreed Arnold. " I wonder what happened to the poor devil. I've had an operator standing by night and day at the television receiver upstairs, but not a thing has come through. But of course the whole thing's fantastic. Mars is 35,000,000 miles away at its nearest. Think of the enormous power required to send wireless signals over that distance. And yet Bullivant seemed confident he could do it. After all, he was clever . . Oh, curse the telephone. *' Hallo ! Who's that ?* Oh, yes, Jones. You say the whole broadcasting system is being jammed by atmospherics. You think it's an electric storm. Yes, you might write it up, we're a bit short of copy. Pad it out if you like.' "

Arnold put down the telephone-receiver and turned to his sub-editor. " Funny we should have been talking about wireless just then. All the broadcasting system is fuzzy to-night with chronic atmospherics, and the authorities are being bombarded with enquiries and complaints. Jones is going to write it up. He's fairly good at semi-scientific stuff."

Voice at Other End of Wire : " I think you've got the wrong number."
" Not if my television apparatus is to be relied upon."—" *Judge*," New York.

There was silence in the room for a moment whilst Arnold bent over his proof—comparative silence, that is, for the whole building shook and rumbled with the thud and clash of the huge rotary printing presses resting on their concrete beds below. Then again the telephone bell rang.

Trouble on the Radio System.

" Answer it, Meredith," barked Arnold, intent on his work. Meredith lifted the instrument, listened intently, and then turned to his chief.

" There's trouble on the trans-Atlantic radio system, sir. Their engineers suspect an unknown station of tremendous power, but very coarsely modulated, working between 300 and 600 metres, as being the source of interference. It's jamming all their messages, and they declare it's certainly not atmospherics."

Arnold was alert at last. He flung down his pen with a crash and stared intently at Meredith, as though some sudden, arresting thought had struck him.

" I wonder," he began, but he got no farther. Heavy footsteps clattered on the stairway outside, and a man, dishevelled, excited, burst unceremoniously into the room. It was the television operator from the room upstairs. Both Meredith and Arnold knew exactly what he was going to say.

" Professor Bullivant is signalling at last, sir. He's landed safely on Mars."

* * *

" Reception was a bit muzzy at first, sir, and even now it's indistinct, with a considerable amount of fading at times, but it's the Professor without doubt," explained the operator. He led the way excitedly into the darkened room, Arnold and Meredith groping their way behind him.

Upon the screen at the far end of the room, for all the world like the unsteady pictures thrown by the first crude cinematograph projectors of half a century earlier, there flickered and wavered, in pale pastel tints, a vision of the Martian landscape, 40,000,000 miles distant, upon which Bullivant's projectile had rudely pitched after its headlong flight through space.

Bullivant himself occupied the centre of the picture, gesticulating dramatically. About him stretched sandy ground, but some hundreds of yards rearwards stood out a broad belt of vegetation and stunted trees.

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These trees struck Arnold at once as sinister, with their long, fleshy, drooping boughs, but his attention immediately wandered to other prominent objects in the picture. On the extreme right, half-buried in thrown-up masses of sand, could be seen the steel projectile. To the left stood a small wooden cross that struck sudden apprehension into Arnold's heart, whilst in mid-picture one of Bullivant's ruffians was carefully oiling a machine-gun. Bullivant's voice, distorted unrecognisably after its long journey through space, was croaking out a message.

A Sensational Message.

" . . . too close. We approached the planet at a frightful pace and fired off . three retarding frontal rockets in quick succession. Even then we fell too fast. As we dropped, I saw the face of the planet clearly. It was a wonderful sight—a huge disc capped with white snowfields at its poles and marked with green irrigated areas and light red sandy deserts, across which ran a geometric grid of canals lined by thin belts of vegetation.

" Schiaparelli and Lowell were right—dead right—about the Martian canals. I saw we were heading for the desert terrestrial astronomers call Elysium, so fired a lateral rocket so as to swing towards the fertile area of Trivium Charontis. Then the ground rushed up towards us and spread out above and below us at an alarming rate. We fired our last retarding rocket but came to ground with a terrific impact that threw us about like ninepins within the padded projectile. We must have ricochetted a mile or more before finally we came to rest.

" You can see for yourselves, I trust, the sort of country in which we find ourselves. I believe we are near the northern tip of Trivium Charontis, in about latitude 20° N. When we emerged from our nearly red-hot projectile into the watery Martian sunlight we wore oxygen respirators, as we doubted whether the air would be dense enough to sustain terrestrial life. We have since found that we do not need oxygen, however, as the air, though thin, is exhilarating. This thin air is a handicap, as our aeroplane will not rise in it until we have added additional wing-surfaces. The climate is bracing, and the fact that our bodies weigh very much less here than on the earth gives us a sense of extravagant vitality.

" One of our first steps was to try and find water. Two of our men, Hester and Smith, discovered a canal 500 yards distant. Unfortunately they observed a number of queer creatures in the neighbourhood and promptly opened rifle-fire on them, killing several and dispersing the remainder. These creatures, which are nothing more or less than enormous ants, 4 feet long, with very large heads, are so far the only signs of animal life we have encountered.

The Masters of Mars.

" On examining one of the dead ants, I was surprised to find that its brain was extraordinarily developed. It would be strange if these huge ants prove to be the ultimate masters of Mars. They seem, however, very peaceful and docile. We have since coralled a whole bunch of them and showed them by signs that they must work for us. Thanks to their labours we have succeeded in erecting our turbo-generator on the canal bank, thus making this television transmission possible.

" I am sorry to report, however, that the first night of our arrival we lost Graves, who was killed by a flesh-eating tree whilst we were admiring the extraordinary beauty of the night sky. Our own planet, Earth, shows up with remarkable brilliance. On the second night, another man, Hester, disappeared, though I had particularly warned him about the trees."

Arnold looked at Meredith. " Well, what do you think of it ? "

" It's wonderful . . . wonderful But don't you think these men are in frightful danger ? These ants may have more powerful resources behind them than Bullivant realises. They may have captured Hester."

" There's no evidence that these ants are dangerous," said Arnold thoughtfully.

" No, but a Martian arriving on Hampstead Heath on a Sunday afternoon would never suspect that the inoffensive humans he could see there could summon up machine-guns, tanks, artillery, war-planes and poison gas before the sun had

(*Continued on page* 100.)

The picture on the screen had become intensely animated. The man at the machine-gun was aiming the barrel sharply upward. Others darted into view, armed with rifles.

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The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. each.

LARGE VIEWING SCREENS.—Where large viewing screens are employed, consisting of banks of lamps successively put into circuit through the action of high-speed commutator switches, it is arranged that one pole of each lamp in a group or line of lamps is connected to the segments of one commutator switch; the other pole of each lamp in further groups being connected to the segments of another commutator switch. Suppose we consider the lamps (13) in Fig. 1 to be arranged in horizontal rows (*x*) and vertical columns (*y*). All the lamps in one of the rows (*x*) are connected to one particular segment (6) of the switch (2). The other pole of each lamp is taken to one or other of the segments (8) of a second switch (4), the common return wire of each column of lamps going to the same segment. In operation, the switches are mechanically connected so that after one commutator switch has been swept, the second advances one segment and the first switch is then swept again. The lamps are thus joined up selectively to the battery circuit (14), upon which circuit the television signals

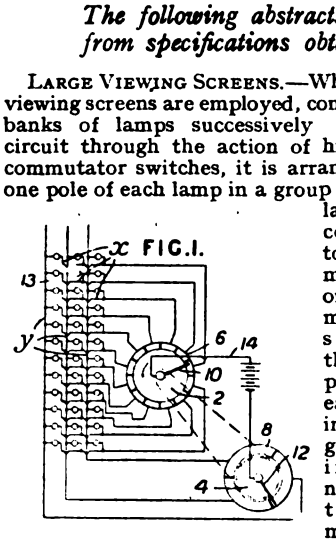

FIG. 1.

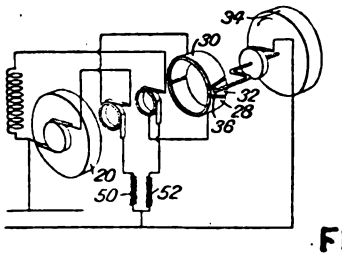

FIG 2

are impressed. The foregoing details are given in *Patent No.* 302,187 granted to J. L. Baird and Television, Ltd.

MOTORS—CONSTANT SPEED CONTROL.—For driving motors at a pre-determined speed, a direct-current motor (20) in Fig. 2 is automatically controlled by a rotary contact device resembling a commutator with two long segments (28) and (30) and short tapered intermediate segment (32), the whole being driven by the motor (20). A rotary brush (36) driven by a constant speed master motor (34) remains in contact with the segment (32) so long as the speed of the motor (20) is equal to that of the master motor. If it lags or leads, the brush moves into contact with one of the segments (28) or (30) which short-circuit resistances (50), (52) in the armature and field circuits respectively of the motor (20). Axial adjustments of the brush (36) increases or diminishes the delicacy of the speed-control *Patent No.* 301,847 granted to J. L. Baird and The Baird Television Development Co., Ltd.

PHOTO-ELECTRIC CELLS.—The three applications for patent rights which we shall next consider, deal with improvements in the construction and manufacture of photo-electric cells. *Patent No.* 302,183 (Convention Date, Germany,

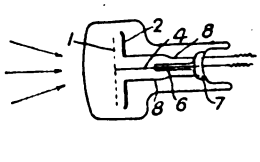

FIG. 3.

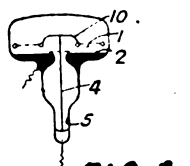

FIG. 4.

Dec. 9th, 1927) in the name of O. Pressler, indicates two methods of mounting the anode within the cell and its relative disposition with regard to the cathode. In Fig. 3, the anode (1) on which the electron stream is caught, passes through the sensitized cathode (2). The anode lead (4) and that for the cathode (8), are sealed into the same pinch (7). To prevent accidental discharge between the two leads, the anode is surrounded by a long glass tube (6). In the cell illustrated in Fig. 4, the active material forming the cathode (2), is cast in position as shown. The anode lead (4) passes through a tubular extension (5) of the cell. The anode (1) has a central opening and the supports (10) are bowed so as to increase the distance between them and the cathode.

Patent No. 303,476 (Convention Date Jan. 4th, 1928(?), (U.S.A.) applied for by The British Thomson Houston Co. Ltd., relates to the method of depositing a layer of silver on the inside of a 'flask-shaped' cell and providing a window through which the light may enter the cell. The process is illustrated in Fig. 5.

A silver bead attached to a filament (4), is vaporised (by the passage of a current through the filament) and deposited on the envelope. The anode, in the form of a disc (6), besides acting as an anode prevents at this stage of manufacture a deposition of silver coating taking place in one direction which in effect forms the window (5). Similarly a mica or quartz washer (7) mounted on the filament supports, prevents deposition on the neck of the cell. The silver coating is oxidised by admitting oxygen to a pressure of 100 microns of mercury and applying a spark coil so as to produce a discharge, or heating the envelope in an exhaust oven to 360°C. for a few minutes. After excess oxygen is pumped out, the foundation layer of silver is coated with a layer of cæsium, rubidium, potassium or calcium; the light-sensitive metal being distilled into the envelope by heating the metal in capillary tubes (9), secured to a metal disc (11) by straps (12). Excess alkali metal is removed by connecting the envelope to an exhaust pump and heating to 300°C. for a period of time varying from a few minutes to two hours, and depending upon the amount of alkali metal present. When barium is used as the light-sensitive metal, the envelope is made of quartz and is heated to 700°C. In *Patent No.* 300,918 (Convention Date Germany, Nov. 17th, 1927) in the name of O. Pressler, several methods of depositing potassium on the cathode are given.

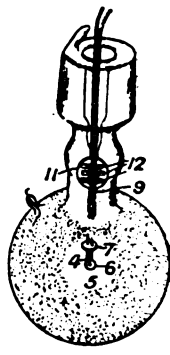

FIG. 5.

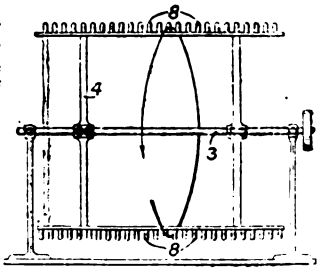

FIG. 6

IMAGE FORMING DEVICE.—A novel form of image-forming device is the subject of an application *Patent No.* 303,178 by L. Thurm (Convention Date, France

(*Continued on page* 100.)

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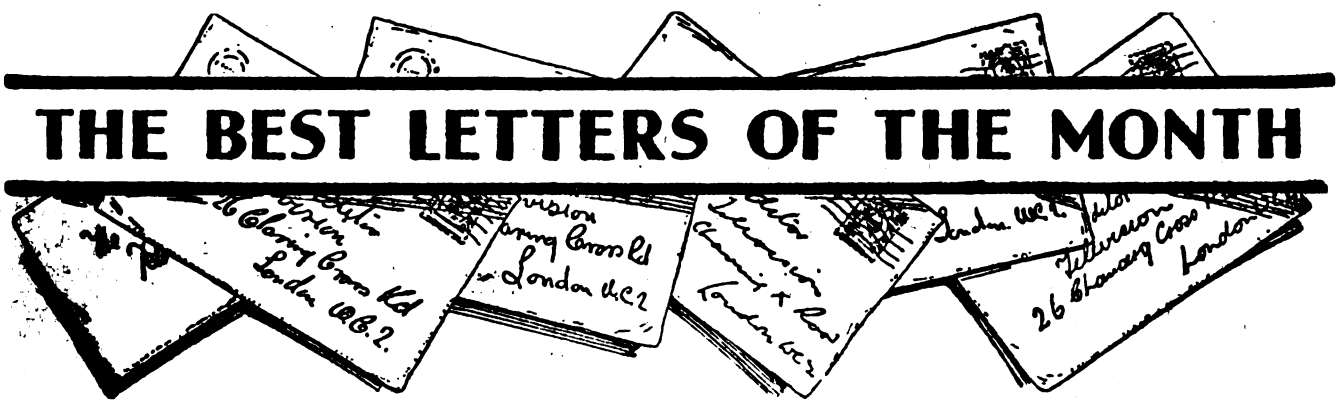
THE BEST LETTERS OF THE MONTH



The Editor does not hold himself responsible for the opinions of his correspondents. Correspondence should be addressed to the Editor, TELEVISION, *26, Charing Cross Road, W.C. 2, and must be accompanied by the writer's name and address.*

J. B. SHREWSBURY'S SUGGESTION.

109, CAMPDEN HILL ROAD,
KENSINGTON, W.8,
March 7th, 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

For the past four months I have been deeply interested in the scheme expounded by Mr. Shrewsbury in your November issue, and the subsequent correspondence with regard to the substitution of short "wireless waves" for the light used for scanning the object.

It may interest other readers to learn how this matter appears to me.

If we endeavour to transmit a *very* short "wireless" wave—and as Miss Everett has pointed out in her letter reproduced in the February issue, it must be a *very* short wave indeed, for reasons which Mr. Shrewsbury seems to have overlooked—we must have a "tuned circuit" in our transmitter, in which the capacity and inductance are very small values.

Hertz transmitted and received a short wave by using a "tuned circuit" consisting of approximately one metre of thick wire, and this wave from such a small L.S. value was very considerably greater than a wave on the visible spectrum. We are told the wavelength of light is 200,000 shorter than this wave used by Hertz.

It seems evident that to get down to a wavelength which will give reasonably good reflection and gradation of light and shade, the tuned circuit of our transmitter will be either a small piece of metal primed into an inductance or, say, an air space having a small capacity.

Supposing, having decided upon the length of our wave, and figured out the L.S. value, we decide to use a thin wire formed into a coil.

If we apply potential to the ends of our coil—provided it is made of a metal such as tungsten, in order that a potential sufficient for practical purposes may be applied—we shall be able to transmit a very short wave.

Our little coil we shall find will give better results if enclosed in a vessel from which the air is excluded, and far better still, if the vessel contains a little of the gas "argon," for then we can work our transmitter at a much higher temperature.

Our receiver must have an equal L.S. value to that of our transmitter, and I propose we use a small metal plate. We shall find that our apparatus for utilising the received wave, gives better results by making use of the electron stream emitted by the plate when excited by the incoming wave, than by direct connection to the plate.

It should be patent to all having read the foregoing, that our transmitter is a gas-filled lamp and our receiver a photo-electric cell!

"This," you may say, "is pure balderdash." "The filament of a lamp is just resistance." "And what about an arc lamp?"

To which I reply by asking, is not the resistance of the dielectric an essential part of a condenser, and is not an arc merely a form of low capacity condenser?

If we bring two conductors of electricity nearly together we get a luminous discharge. Do not the ends of these two conductors constitute the plates of a condenser?

There are, of course, other factors which enter into these questions, and the foregoing theory may be entirely wrong. It is, however, I think, advantageous to advance theories of this kind as they may be the means of arriving at the true position through the controversy which generally arises.

With regard to the scheme put forward by Mr. Adcock for heterodyning light waves, I would like to suggest to him that by filtering two sources of polychromatic light through, say, cobalt and ruby glass, he will get a heterodyne effect. The colour of light does, of course depend upon the frequency, and the velocity of light is constant for all wavelengths. So by focussing the two colours upon a reflecting surface he will obtain a third colour which will be different from the two filtered sources, and hence of a different wavelength.

I doubt very much if even by repeatedly heterodyning the products of separate filtered sources, a wavelength as high as one metre will be obtained, and should Mr. Adcock succeed, the intensity of the variations of the original light from the object being televised, would be considerably diminished.

The idea is certainly a very good one, and although it may not be possible to produce a wave by this means high enough to eliminate the photo-electric cell, it may make possible the use of a more robust type of cell.

I hope Mr. Adcock will let us know if he has any measure of success.

Wishing every success to a very interesting and well-conducted journal.

I am, Sir,

Yours faithfully,

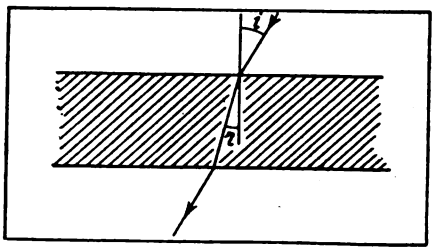
A. C. FINER.

GRENEHURST PARK,
CAPEL, SURREY.
February 8th, 1929.

THE EDITOR,
TELEVISION.

DEAR SIR,

Mr. E. P. Adcock's letter interested me greatly, but he does not seem to have grasped the idea of refractive index.



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Let a beam of light be incident on the given medium. It can be shown that the

$$\frac{\text{sine of the angle of incidence}}{\text{sine of the angle of refraction}}$$

is a const. for the given medium, where i = ∠ of incidence, 2 = ∠ of refraction.

This constant is called the refraction index, and is usually denoted by μ. Different media have different refractive indices.

$$\text{Hence } \mu = \frac{\sin i}{\sin 2}$$

It can also be shown that $\frac{\sin i}{\sin 2} = \frac{v_1}{v_2}$

Where v_1 and v_2 are the velocities of light in the two media under consideration.

$$\text{Hence } \mu = \frac{v_1}{v_2}$$

$$\text{or } v_1 = \mu v_2$$

Mr. E. P. Adcock states that—

$\lambda = \frac{v}{n}$ where λ = wavelength of light. v = its velocity. n = its frequency.

This may be rewritten $v = \lambda n$,

or, writing v_1 instead of v, $v_1 = \lambda n$.

But we have shown that $v_1 = \mu v_2$.

$$\text{Hence } \mu v_1 = \lambda n.$$

Therefore, on passing light through a medium of refractive index μ, neither the wavelength nor the frequency is altered, and so the colour of the light remains unchanged.

Yours faithfully,

C. M. ADCOCK.

HEADINGLEY,
LEEDS.
March 2nd, 1929.

THE EDITOR,
"TELEVISION,"

DEAR SIR,

In reply to Mr. Adcock's letter, published in your March issue, which is full of contradictions. While in para. 2 he agrees with me, he proceeds, below the formula in para. 7 to disagree with me by restating his idea, which, as I said before, is totally erroneous.

Mr. Adcock's stumbling-block, and the apparent "flaw," is due to his misunderstanding the import of the equation which he gives as $\lambda = \frac{v}{n}$ Here the term v stands for a constant; indeed, in the usual rendering of this formula, the letter c is used, as conveying the idea of the constant. This constant is the *velocity of light in air*. This cannot change—it is an universal constant, value 3×10^8. It would be fatuous to suppose that one could replace it by any other figure, and though the velocity of propagation of the light wave under consideration may change, this new velocity cannot be substituted in a formula which depends on the one definite value given above.

If I dare venture another analogy, I would point out that its value is just as definite and constant as the value of π, or of Planck's constant h. The idea should not be difficult to grasp, and it will explain all your correspondent's difficulties and mistakes.

Now most people who have had anything to do with Radio—and who has not—know that a definite frequency is associated with every definite wavelength. It is absurd to talk about waves with the same frequency and different wavelengths. Such a thing is impossible. Mr. Adcock must know, I am sure, that frequency and wavelength are only two ways of expressing the same thing. They are correlated functions. λn = const. $= 3 \times 10^8$, is only another way of expressing the formula, and is obtained by cross-multiplication. There is no difference made by interchanging λ and n, as is done in the first para. on page 48.

No, sir, it is not possible to obtain a heterodyne with two waves of the same frequency (which means that they are of the same wavelength) and of differing velocities. A heterodyne is a beat-note set up as a result of the difference in *frequency* of two waves. This is well known in the case of audible waves, as in the tuning of a piano by the method of beats, when the tuner determines the difference between his fork and the piano wire by noting the frequency of the beat. This is of the order of five per second in the case of piano-tuning. If F is the beat frequency, and f_1 and f_2 are the frequencies of the two waves, then $F = f_1 - f_2$. Thus F must always be less than either f_1 or f_2.

Your correspondent cannot be aware of the subject of interference fringes, though this is widely known and is dealt with in elementary text-books. The compensation of waves which are $\frac{\lambda}{2}$ out of phase, and the reinforcement when they are λ out of phase, is the well-known explanation of this phenomenon, and is due to waves of the same frequencies, but different velocities, producing this effect, which is in no way comparable to a heterodyne.

With regard to his disagreement with my analogy, which he misquotes in para. 1 on page 48, no analogy is absolutely perfect, but analogy does not, I never did, nor was it intended by me, convey the idea of synonymy. Then, too, unit quantity of electricity is *not* measured in amperes, but in amperes *per second*, or more generally, per unit time. Q = it, where i is the current.

With reference to the copper-plate or gauze theory, my original arguments hold; the current induced would be the integral of all the separate currents, and we have only to apply Kirchhoff's laws to show that the current at any *point* in a network will be zero.

Even if this were not so, there is no method of transforming a current, induced at a point, into light.

I am sorry if my letter reads like a load of bricks, or suggests that I am trying to discourage your correspondent; but, frankly, I would advise him, for his own peace of mind, to refrain from rushing into print with unfermented ideas, and unverified "facts."

Yours faithfully,

H. WOLFSON.

Invention and Development.

(*Concluded from page* 98)

Dec. 30th, 1927). The scheme is shown in Fig. 6, where two or more rows of neon or other lamps (8) are arranged on a frame (4). This frame can be revolved about an axis (3) and the rows of lamps are relatively staggered, and the lamps themselves are illuminated in succession during a limited arc of their path under the control of the received vision signals, so that they trace out the successive lines of a picture.

Various modifications are suggested; there may be, for example, more than two arms; the lamps may be mounted on an endless chain or flexible band; or the rows of lamps may be replaced by long neon tubes having a number of electrodes.

A Message from Mars.

(*Concluded from page* 97)

set. To me, Bullivant's rather high-handed behaviour means simply asking for trouble. He can't have touched the real Martian civilisation yet."

The Attack.

"That's true enough," agreed Arnold. "But there's no doubt that Bullivant's whole idea is to seize control of the planet. Hallo, what's happening?"

The picture on the screen had become intensely animated. Bullivant had leapt forward and a rifle glinted as he took aim into the sky. The man at the machine-gun had sunk on to his knees and was aiming the barrel sharply upwards. Others of Bullivant's crew had darted into sight, also armed with rifles.

"This means trouble!" ejaculated Arnold tensely.

The rifles began to splutter and crackle in straggling volleys—Crack-crack-crack! Then the machine-gun joined in the din with its murderous Tat-tat-tat-tat . . . Tat-tat-tat-tat. And now those watchers in that London room saw at last the menace that threatened those distant pioneers of terrestrial civilisation.

From over the belt of trees that fringed the distant canal there poured a host of flying giant ants, each riding on a light sort of aircraft, and ranged in regular formations that moved up across the sky with an ominous persistence. One or two seemed to drop out as the rifle and machine-gun fire caught them, but the main host advanced as irresistibly as a flight of locusts. Closely packed in the heavens and flying at a low altitude, the ants visibly darkened the sky, and the drone of a multitude of rotating wings overwhelmed the puny explosions of the rifles.

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Panic.

Panic obviously seized upon Bullivant and his men; ey threw down their arms and bolted wildly toward's e projectile, whose gaping entrance stood open, but in e confusion they jammed together in one struggling ass. Bullivant felled one of his followers with a terrific ow between the eyes. The next moment the locust-like oud seemed to fall out of the sky, and the doomed men ere hidden in seething waves of tearing, fighting, ant ants.

"Switch the thing off," moaned Meredith. "I can't ok."

But Arnold continued to stare at that dreadful tragedy though fascinated. Then a crawling ant seemed to bserve the televisor as if in surprise, and came slowly nd steadily towards it, his scaly features growing larger nd larger until they almost filled the screen. For a noment his weird face, lit up with ferocity and yet with a ueer intelligence, was turned full on Arnold, the red nt-eyes glaring defiantly into his own. And then, with ramatic suddenness, the picture faded and flickered out.

* * * *

Many months have passed since that strange message nd vision was received from Mars at Argus House, and o further communication has come since. On Arnold's nstructions the apparatus is always kept in order, but he s inwardly certain that Professor Bullivant will never gain signal to his mother planet, the Earth.

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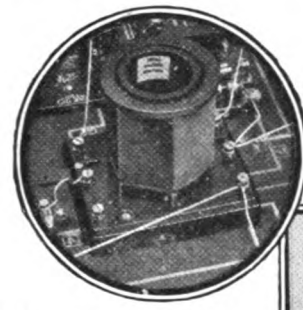

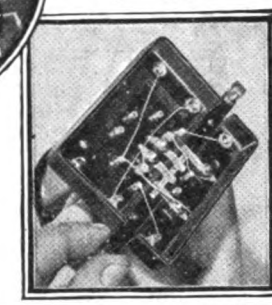

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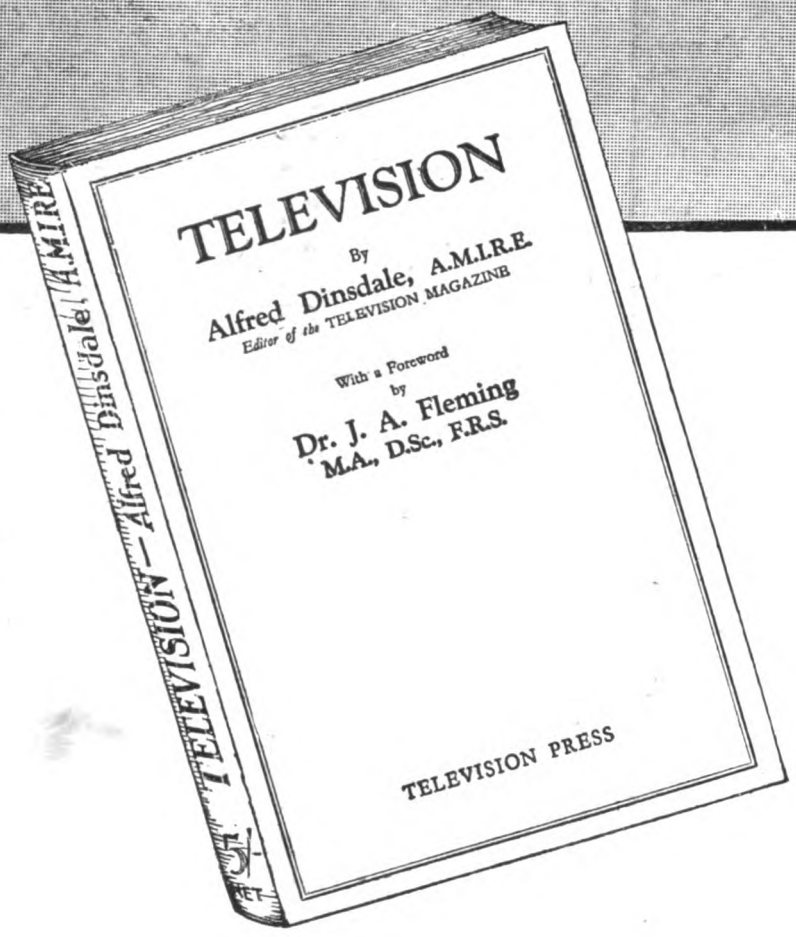

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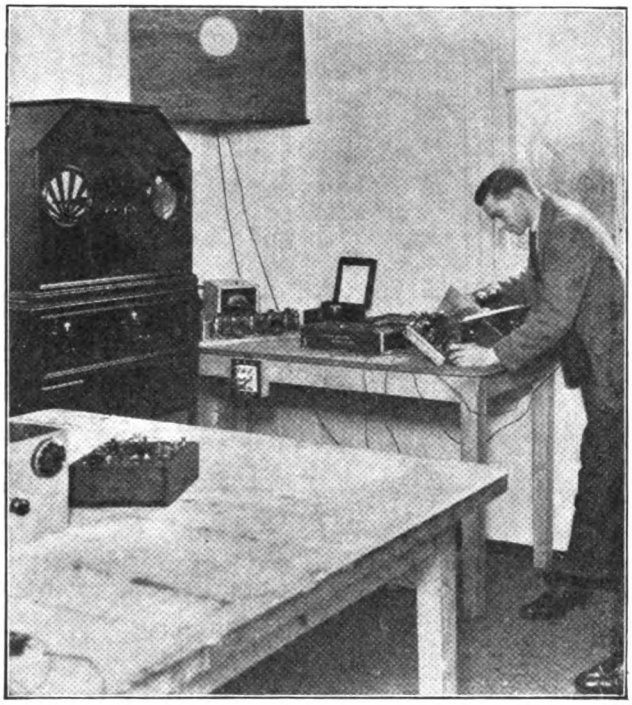
The Official Organ of the Television Society

VOL. 2 MAY 1929 No. 15



A Research Engineer engaged in Testing a Televisor at one of the Baird Company's Laboratories situated on the outskirts of London.

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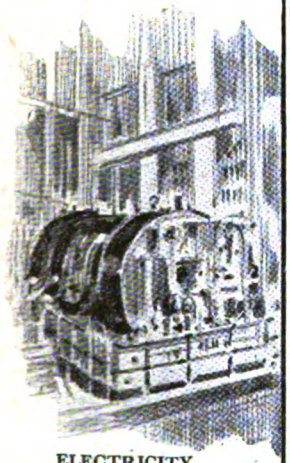

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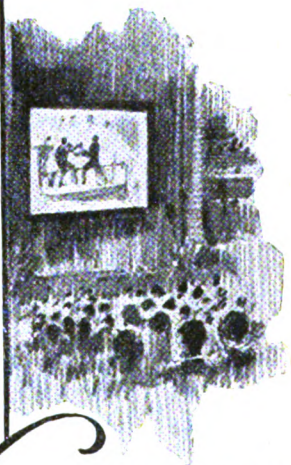

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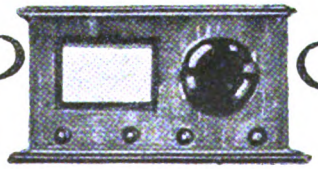

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The Official Organ of The Television Society

Edited by A. DINSDALE, A.M.I.R.E.

Consultants: Dr. C. TIERNEY, D.Sc., F.R.M.S.; W. J. JARRARD, B.Sc. (1st Hons. Lond.), A.R.C.S., A.I.C.

Technical Editor: J. C. RENNIE, B.Sc., A.M.I.E.E.

Vol. II] MAY 1929 [No. 15

EDITORIAL

BROADCAST FACILITIES GRANTED.

IN our last issue we placed before our readers the latest available information about the official test by the Postmaster-General and the B.B.C. of the Baird system of television. Since that issue was published our readers have no doubt read in the daily press the terms of the P.M.G.'s decision. We reproduce on another page the full text of his letter to the Baird Company. We regard the decision as being in every way fair and just.

* * *

AFTER outlining what the Baird system of television proved itself on the occasion of the test to be capable of doing, he goes on to point out the limitations of its scope at present. With that statement we have no quarrel; the record of all great inventions shows that many years are required to develop them to "perfection" and enlarge their scope. In our opinion Mr. Baird is to be congratulated on having, within such a short space of time, brought his invention to the stage of development which it has reached to-day.

* * *

THE Postmaster-General considers that the system represents "a noteworthy scientific achievement." Coming from one of His Majesty's leading Cabinet Ministers this is high praise indeed. But he does not consider that television should immediately be introduced into regular broadcasting hours. He is, however, anxious that facilities should be afforded for continued and progressive experiments to be made with the Baird apparatus, and agrees to the use of one of the B.B.C. stations for that purpose. The B.B.C. also agrees in principle to this proposal.

* * *

TWO STATIONS REQUIRED.

THE Postmaster-General also recognises the fact that, in addition to the station broadcasting television, another station will be required to broadcast the accompanying music, singing, or speech. So far as London is concerned, it will not be possible to provide a second station until the new B.B.C. regional station at Brookman's Park is completed in July.

* * *

THE P.M.G. further suggests that it may be necessary to employ for the broadcasting of television wavelengths outside the normal broadcast waveband, which is already congested. He recommends that experiments be pushed forward on "a much lower band." We may therefore expect a revival of interest in wireless reception on wavelengths below 250 metres.

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IN summing up the whole of the P.M.G.'s letter there are those who choose to regard it as being unfavourable to the Baird system. We do not share that view. One must expect a certain amount of extreme caution when the head of a Government Department places his seal of approval on the product of a commercial company and recommends that the facilities of a semi-government organisation be placed at that company's disposal for the purpose of conducting further experimental work.

* * *

OUR POLICY BEARS FRUIT.

AS our readers well know, we have consistently urged that broadcasting facilities be granted for the Baird system. More recently we have pleaded for the recognition in this country of a British invention and pointed out that unless this recognition was granted speedily our Continental neighbours were certain to experience the benefits of this British invention before we did, in the country of its origin.

* * *

WE felt very keenly on this matter, for we do not belong to that body of persons which delights in lauding *anything* of foreign origin in preference to something invented and produced in this country. As a result of our stand we have, in the past, been a greatly discredited journal. In future, we trust, we shall be regarded in a totally different light. We have reached this stage, not by spectacular methods, but by the force of solid conviction. It has been a war of attrition—and we were prepared for it when we first took up our stand.

* * *

A NEW BOOM AHEAD.

OUR wireless contemporaries are at last beginning to realise the truth of one of our contentions—that the introduction of television into the broadcasting service will revitalise a flagging industry. With the advent of television we predict that the biggest boom which this country has yet experienced is about to start in the wireless industry. Those who possess a wireless receiver for the reception of sound broadcasting, and wish to receive television as well, will require a second receiver; and those who are already the possessors of two receivers will require a power amplifier. The subject of H.T. battery eliminators (to which we have been devoting some attention in these pages) will also have to be considered more seriously, and in a new light, for two receivers must now be supplied with H.T. current.

* * *

THE wireless journals have adopted towards the P.M.G.'s letter a very praiseworthy attitude, upon which we congratulate them. We reproduce below some extracts which express their views.

* * *

"A NOTEWORTHY SCIENTIFIC ACHIEVEMENT."

The Postmaster-General is to be congratulated on his excellent summing up of the recent official tests carried out between the Baird Television Development Co., Ltd., and the B.B.C. The purport of his communication to the Baird Company indicates that we can look forward to real "seing-in" in a relatively short time. With television as an ally, broadcasting will take on a new interest.

The other day I read an article in an American paper which questioned whether wireless broadcasting would be so effective if it were accompanied by television. Summing up the situation, the writer held that he who travels by the wireless with imagination for his guide may enter into those realms of gold which are closed to those who, seeing all, blindly seek a certainty.

DOUBLY GIRDED.

I am afraid, however, that the arguments put forward were far from convincing. Imagination is a wonderful asset to the individual when applied in the right direction, but to use that as an excuse for discounting television is certainly wholly wrong. To the amateur this new science opens up what may be regarded as a virgin field of investigation, and for that reason alone we shall welcome its appearance. Of late, I have been making a careful study of the problems involved and find that once the elementary principles are thoroughly understood "seeing by wireless" is really only slightly more complicated than sound reception.—*Amateur Wireless*, April 13th, 1929.

. . . .

We consider this to be a very fair and proper attitude for the Postmaster-General to have adopted, and it now remains to be seen what arrangements can be come to as between the Baird Company and the British Broadcasting Corporation to provide for experimental transmissions outside broadcasting hours.—*Wireless World*, April 10th, 1929.

. . . .

It now seems very likely that Baird television will become a permanent part of B.B.C. transmission. The Baird people won such a complete political victory that no amount of technical obstruction can prevail, however well-founded. Fortunately, however, there is no disposition to revive any of the bitterness of the previous period of hostilities between Savoy Hill and Long Acre. What will happen will be something like this. The Baird and B.B.C. engineers will begin at once the preliminary experimental and installation work. In July there will be transmissions in London, with one low wave and one of the new regional waves. These experimental transmissions outside programme hours will last for about a year, after which television will be made a part of the regular programme service along with Fultograph, each adapted to its special use. Now that the B.B.C. has taken up the Baird method, it has received great impetus abroad, and there is something in the nature of a world monopoly being attempted by Lord Ampthill, Sir Edward Manville, and their colleagues. Incidentally, it was a curious sight to see Captain Eckersley dining with Mr. Baird in the Savoy the other night. Apparently the hatchet is properly buried. Another moral to be drawn from the incident is that the Post Office, when it likes, does dictate to the B.B.C.

. . . .

VALUABLE STIMULANT TO B.B.C.

Nevertheless, despite enthusiastic supporters of television who have worked themselves at times into a very fine rage over the criticisms of television which have appeared in this and our contemporary journals, and who have accused us on more than one occasion of doing our best to crab television, and to display antagonism to Mr. Baird and his associates, we take this opportunity of congratulating Mr. Baird and Captain Hutchinson, his managing director, on the generally successful result of the recent test, and to express the hope that if and when facilities are given them for experimental broadcast transmissions, some practical solution to the wavelength difficulty will soon be found and that on the whole progress will be made satisfactorily enough to warrant the B.B.C. including television transmissions in regular programme hours in due course.

Should the Baird system . . . be brought to such a test of technical practicability which would warrant the B.B.C. making regular broadcast television transmissions in programme hours, broadcasting in general would receive a great fillip. The trade would benefit, public interest would be revived, and a new and very intriguing aspect of wireless technique would be opened up for the general amateur.

. . . .

The recommendations of the Postmaster-General seem to be eminently satisfactory.—*Popular Wireless*, April 13th, 1929.

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A QUANTITATIVE ANALYSIS OF TELEVISION

By J. H. OWEN HARRIES, A.M.I.R.E.

The following article is of considerable interest to all students of television. It is one of the first serious attempts to get to grips with the problems of television on a quantitative basis which we have seen. The writer submits his arguments tentatively, and would greatly welcome discussion on his paper. To that end we shall be very glad to place our correspondence columns at the disposal of readers who wish to discuss Mr. Harries' thesis.

Introduction.

1. The basic principle of television, as it is at present known, may be summed up as follows :—

A series of pictures have each their two geometrical dimensions of length and breadth analysed into what may be termed two corresponding dimensions of time and magnitude. In this form the pictures are each transmitted to the receiver where they are synthesised into geometrical two-dimensional pictures again.

When discussing various systems of doing this the usual form of statement is that a certain size of picture will be transmitted clearly with a given type and efficiency of analysis and method of transmitting the time dimensional form, or modulation, of the pictures sent. In this statement the terms "size of picture," "clearly" and "efficiency of analysis" have not been given the requisite degree of definiteness to enable one to apply the methods of mathematics to the consideration of their relationships, and to the devising of the mechanism to carry out the work we wish to do.

This paper is an endeavour to define and express these ideas, and others, mathematically, thus giving a series of simple equations capable of fulfilling the same function in this specialised field as, for instance, Ohm's law does in electrical engineering. This results, briefly, in making possible numerical measurements of the relative efficiencies of different television and photo-telegraphic systems with reference to any selected standard ; of the relationship between these and the transmission channels needed ; of the fields of view and picture sizes possible ; and other points.

Examples of practical results are also given.

Definition of Picture Size.

2. The term "picture" is intended to mean any two dimensional (i.e., flat) image of any object or scene.

From the elements of optics it is obvious that the angle the picture subtends to the eye is the true measure of its effective size from the point of view of its visual effect, and not its size expressed in some arbitrary terms of linear measurement.

Then if we have an object of height h at a distance r from the eye its height by this standard equals $\frac{h}{r}$ radians.*

It follows that the area of a picture may be also expressed by the product of its two dimensions in radians.

In illustration of this (Fig. 1) shows the various effective sizes of a 12-ft. high screen in a typical cinema theatre to members of the audience seated in different parts of the building.

For the rest of this paper the picture dimensions will always refer to this effective or "angular" size in radians unless otherwise stated.

It will be realised that it automatically allows for large or small distances between audience to screen.

For instance, a 3×3 inch screen, seen 12 inches from the eyes, has just

* Strictly speaking, of course, "radian" refers to the length of the arc of radius r, and is merely used here for lack of a better word. At the angles employed, however, the difference between the two values is negligible.

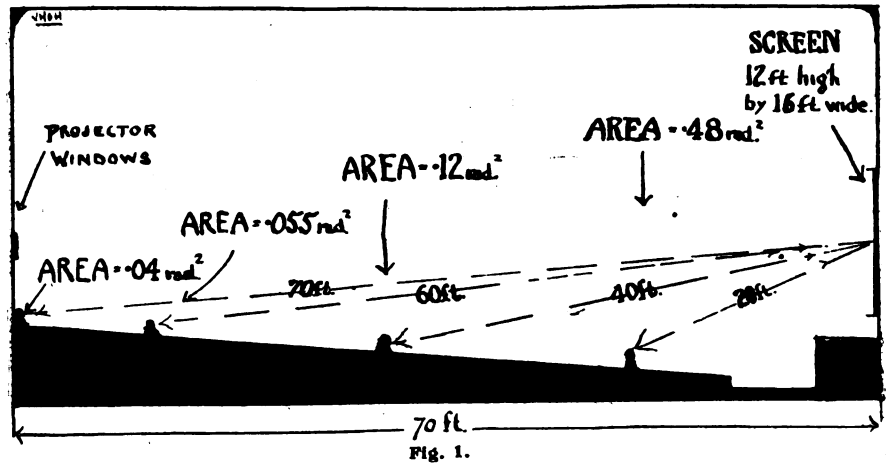

Fig. 1.

Elevation of a cinema theatre. Angular areas of the screen in radians² at various distances.

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the same angular area as a 3×3 foot one at 12 feet from the eyes, and so on.

To find the angular area of a picture of linear size, say, a inches long by b inches wide: measure r in inches, then the area is—

$$A = \frac{ab}{r^2} \text{ radians}^2 \quad . \quad . \quad . (1)$$

Resolution of Picture Detail by the Eye.

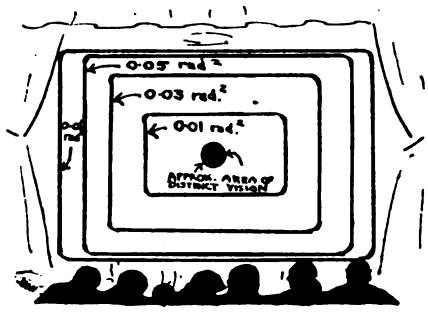

Fig. 2.

Picture areas in radians[1]. If this is held 10 inches from the eyes the areas will be as marked. Note that if the picture is reduced in size in reproduction, this distance must be reduced proportionately.

3. The eye will be found to fail to distinguish the details in a picture where such details subtend a smaller angle to the eye than a certain amount.

If we have two dark dots on a light ground, or two luminous dots on a dark background, they will appear as one dot only when the angle subtended between them is less than about 1/3000 radian.

For example, the dots in a half tone reproduction of a photograph are only visible if the picture is close enough to the eye for it to resolve them in this manner.

It may be of interest to remark in passing that this does not mean, for instance, that if we have a picture built up of strips all of the same width and with no contrasting colour between them their breadth will have to be less than 1/3000 radian to give a continuous effect. This will be referred to later.

Optimum Picture Size.

4. If the received image on a televisor had an area equal to the field of view of the observer, then, obviously, he would appear to be looking straight out into the scene being transmitted, as it were; i.e., there would be no sensation of looking at a limited sized or "framed" picture.

If stereoscopic effects, etc., and colour were also added the observer would be apparently projected straight to the distant scene, and we should have reached the limit of faithfulness in the reproduction of that scene.

Such an ideal is practically an impossibility as far as the writer knows at present, because the area is limited by transmission and other difficulties.

"Comfortable Vision."

Therefore we must endeavour to find the optimum area for comfortable vision. "Comfortable vision" depends not merely on the clearness of the picture, but (especially if this portrays movements which must be followed with close attention) on the distance over which the eyes must be moved to cover the area of the picture with the point of distinct vision. Since the angular area of the picture is limited severely by practical difficulties the movements of the object being transmitted are generally arranged to cover the greater part of the picture in order to make the details of the movements as large as possible to the eye.

The magnitude of the movements of the eye necessary to cover the whole of the area of a picture will be realised when it is pointed out that the angular area of distinct vision is only about 0·0004 radian[2] (see Fig. 2). The fatigue felt in rapidly examining a wide field of view in order to follow changes in its nature is very great if the movements are kept up for some time. For this reason one feels the tiring effect of following the path of the ball in a game of tennis if one is too close to the net between the players.

Optical Mobility.

In a televised picture we must be able to follow rapid changes all over its area with no undue difficulty for a long time. The question now is what is the largest area which we can examine all over continuously and without trouble? It obviously depends on the mobility of our eyes, and fortunately we can easily deduce it from our everyday experience with an accuracy sufficient for our purpose.

For instance, the page of an ordinary newspaper is divided into columns of print because of the effort which would be felt in moving the eyes over lines running across the whole page. The angular length of a line in the usual sized book is about 0·25 radian. The columns in a newspaper are about 0·15 radian. The tiring effect of reading the few books having much longer lines is easily noticeable.

Further, consider the cinematograph theatre sketched to scale in Fig. 1. Here the best seats are usually those nearly at the back of the hall.

Here the angular length of the picture will be about ·2 to ·3 radians, once again. (Most movements portrayed occur in the horizontal direction of the picture). The height-to-length ratio of the screen is 0·75, giving an angular area at the best seats of about 0·05 radian.[2]

Since all these sizes have been found by experiment throughout many years we may take them as a reliable guide to the angular area of a television screen.

Resolving Power of the Eyes.

Some people's eyes have so low an acuity, or resolving power, that they may need a larger area of picture to enable them to see the details—i.e., the area of maximum definition (further explained later on) of a given reproduced picture will be much larger for their eyes than for the normal person's. Hence, they may prefer to be closer to the receiving screen than normal-sighted persons need to be, despite the extra fatigue of moving their eyes over the larger area. Such people prefer the cheaper to the more expensive seats in a cinema.

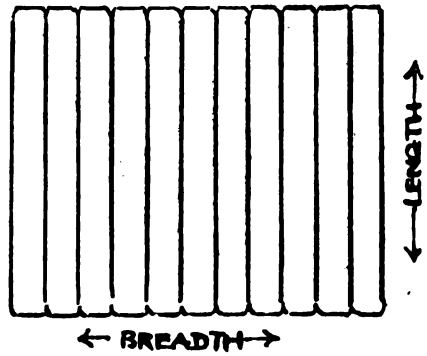

Fig. 3.

A televised or telegraphed picture is built up out of strips. Note the convention adopted for length and breadth with reference to the direction of the strips.

The only final criterion must be the more or less indeterminate physio-

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logical, as well as the exactly measurable physical, phenomena.

In the practical examples given later it is proposed to work to an area of 0·05 radian.[2]

This is better than any televisor has yet attained, so far as the author knows, and, if necessary in the future, the methods of computation to be given apply equally well to any size.

It was obvious that before we could hope to devise the formulæ men-

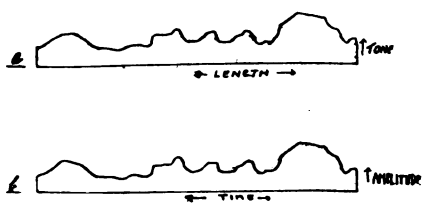

Fig. 4.
An imaginary graph of the picture tone over the length of one strip.

tioned in the introduction to this paper as being so desirable we must have a quantitative measure of picture size.

We may sum up the points so far explained as providing just such a measure, and also as showing the values of it to be expected in practice.

The unit is chosen to allow for the optical theory of vision as regards the effective size of objects seen. The question of the effect of the limited resolving power of the eyes has also been touched upon as far as it concerns the purpose in hand.

This brings us to the next factors in the equations, namely, first, the type of analysis of the pictures, and, secondly, the measurement of their ability to reproduce the transmitted image, i.e., their "clearness."

Fig. 2 illustrates some typical screen areas. The 0·75 height-to-length ratio used in the cinema is shown.

Types of Picture Analysis and the Corresponding Modulation Forms.

5. The type of the analysis of a picture may be defined as the nature and arrangement of the elements out of which the received picture is built up.

The picture modulation may be defined as the shape of an amplitude/time graph of the current which transmits these elements from transmitter to receiver.

By the tone of the picture is meant the intensity of its visual effect, i.e., light and shade.

The essential feature of any known system of television is that the picture is divided into strips sufficiently narrow and close to one another to, partly at any rate, blend into a whole; and each strip varies in tone along its length in accordance with the variation of the picture tone itself over that area (see Fig. 3).

The questions of picture analysis and transmission will not be discussed in detail in this paper, but it will be shown that, by means of the quantitative ideas already given, and ordinary electrical theory, important data on these points may be obtained, and, the author hopes, various controversial points settled.

Scanning Strips.

In Fig. 4*a* we have an imaginary graph of this picture tone over the length of a strip. Fig. 4*b* shows the exact similarly shaped current/time graph of the corresponding picture modulation in the case of a perfect scanning device. (For instance, an infinitely small hole in a scanning disc. A finite-sized hole will "average," or blur, details of the strip smaller than itself.)

By means of suitable scanning arrangements we may cause the picture modulation shape to consist of a series of steps, or "dots," the average effect of which may approximate to the correct shape.

The writer terms the former type of scanning (in Fig. 4*b*) "continuous" scanning, and the latter "intermittent."

In the rest of this paper we wish to show the relationship between the pictures sent and the modulation band widths and the like, with particular reference to finding the miniband width possible in the future.

Now, with a given shape of picture tone/length graph to be transmitted, the "intermittent scanning" *obviously cannot decrease* the maximum rate of change of the graph on which the band width depends, but may be expected to increase it. Then the minimum band width will be that of the tone/length graph itself. Therefore we may conclude that continuous scanning is the basic case which should be considered, as this gives the picture shape itself. (Loss of detail due to a finite-sized scanning hole, as already explained, is neglected because it applies to both methods of scanning.)

Continuous Scanning.

Continuous scanning is assumed in the rest of this paper, though we may note that the equations apply to all forms, if we substitute the band widths of the other method for f_{max} (see on) and remember that here the bottom frequency of the band is not zero. The extension will be quite obvious in other ways and will not be considered further.

The record track on a gramophone corresponds to the picture strip, the needle to the scanning hole, and an electric pick-up to the scanner. Then intermittent scanning is represented by rapidly making and breaking the pick-up circuit, or by the needle only touching the track intermittently. The normal use in a gramophone is "continuous" scanning.

Summing up, the basic type of analysis is continuous scanning, as it results in a picture modulation of the same shape as the picture/tone graph itself, and because, obviously, all other types must reduce to it in essence, plus increases in the band width due to intermittent effects.

We will now proceed to consider the "clearness," which depends obviously on the picture modulation shape and the closeness of the strips of the picture.

Picture Modulation Band Width.

6. We see that the individual strips must be close enough together to blend to the eye. Presuming for the

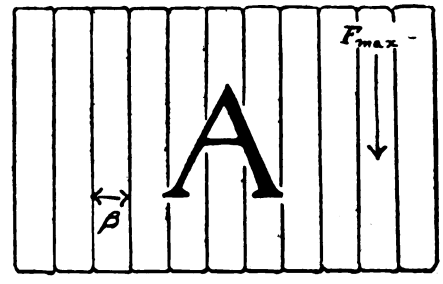

Fig. 5.
The units of measurement shown diagrammatically. A = The picture area in radians². B = The breadth of the strips in radians. Fmax = The top frequency of the modulation band width, i.e., a factor in the measurement of the lengthways definition.

moment that this is arranged for, we will turn to the problem of transmitting the lengthways modulation.

Represented in Fig. 4*a* we have the length/tone graph for an imaginary picture. It is obviously purely dependent on the shape and movements of the object portrayed. Further, since the transmitted image has

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an infinite amount of detail so the modulation must have an infinitely large number of corresponding changes in its amplitude. But, fortunately, our eyes cannot resolve more than a certain amount of detail, so there is a limit to the number of changes in amplitude which need be actually transmitted.

Let us, for simplicity, postulate a given shape of current graph, such as Fig. 4*b*, and consider its transmission. Now suppose the time base is $\frac{1}{a}$th second. Then it is *not* correct, though the author has seen it seriously stated to be so, that the current will behave as one of a frequency of *ab* cycles, where *b* is the number of "bumps" in the curve (in this case six) over the time $\frac{1}{a}$th second. For one reason the term "bump" is too loose to be capable of mathematical interpretation, and therefore has no significance; and, further, because the "frequency" of a current is a term which only applies where the "bumps" are of periodic sine wave form—which, except as a momentary coincidence, can never be the case.

Width of Frequency Bands.

But transmitting apparatus is rated as regards its ability to carry a varying current in terms of the width of frequency band it will pass, i.e., from a frequency of f_1 to another of f_2 cycles per second. Therefore we must express the picture modulations in these terms to find to what extent they can be transmitted.

Fortunately there is the fact that it can be proved that any finite length of current/time graph can be represented as the sum of a certain number of harmonic currents of various frequencies and relative phase angles. Then, if our apparatus will pass these frequencies at these phase-angles (which may be found by mathematical analysis), it will pass the picture modulation they correspond to.

Then, obviously, the frequencies of these currents for a given modulation shape will be proportional to the rate of sending that shape, i.e., the rapidity of the picture scanning by the pick-up device.

For example, let the top frequency of the harmonic analysis of the modulation for a certain number of pictures per second be denoted by f_{max}. Then a doubling of the picture rate will give a top frequency of $2f_{max}$ and so on.

Further, we may note that the fundamental picture length/tone graph will give a modulation of zero frequency when a flat, even coloured area is being transmitted. Hence our transmitter must be capable of passing a frequency band from zero to f_{max} cycles, theoretically.

Breadthways Analysis.

7. Leaving the question of the picture modulation, let us return to the consideration of the strips of which the picture is composed. These are considered to be touching at their edges, and to be graduated along their lengths as previously explained. Consideration will show that if we decrease their (angular) breadth gradually, say, by moving away from the picture, a point will be found where the strips just blend into a whole. Call the angular breadth of the strips at this point β.

Further, the angular area of the picture at this point will be termed the "area of maximum definition" and denoted in radians^2 by A_o (see Fig. 5).

It is a quantitative measure of the ability of the picture to show up details in its breadth—i.e., in the dimension at right angles to the strips.

(Note.—It is not a measure of the details *shown* in the breadth of the picture, since this must depend on the object portrayed).

This is obvious when we consider that reducing the picture below the angular area A_o will merely tend to cause the difference in tone between the strips to be smaller than the eye can see, and an increase of A_o can only show up the strips separately, instead of giving the mass effect we require.

Value of β.

Now β will be a constant quantity for all pictures, and may be found by moving away from a picture composed of strips of known width until they just disappear. Then—

$$\beta = \frac{b_2}{r} \quad \ldots (2)$$

where b_2 = the linear breadth of the strips.

r = the distance at which they just disappear in a good light.

A_o may be likewise observed, or may be found for any picture if the number of strips (denoted by n), in its breadth, is known.

We have then—

$$A_o = \frac{(\beta n)^2 l_1}{b_1} \quad \ldots (3)$$

where

l_1 = the linear length of the picture

b_1 = the linear breadth of the picture.

The writer has found that β should be taken as about 0·00065 to 0·0007 radian.

Hence the ordinary 48-hole scanning disc gives—

$$A_o = \frac{(0{\cdot}00065 \times 48)^2 \times 1{\cdot}5}{1{\cdot}5}$$

$$= 0{\cdot}00097 \text{ radians}^2.$$

This means that the scanning lines on the 1½-inch square picture would be invisible at about 3 ft. 10 ins. from the eyes, which agrees with experiment.

From the point of view of practical measurement it may perhaps be argued that the estimation depends on indeterminate physiological phenomena. But since natural vision is, after all, our sole criterion of success or failure, there seems to be no way of avoiding this. Perhaps a more serious objection will be that in different lights, dim or bright, the acuity of the eye is different. But after all the televisor of the future must give quite a bright light, and so we will not be far wrong if we standardise on the β found by examining trial pictures in a strong white light. This practical estimation will be referred to later.

Area of Maximum Definition.

In passing, the area of maximum definition is not exclusively applicable to televised and telegraphed pictures. For instance, A_o per square inch, is an excellent measure of the merit of the process of reproduction of printed pictures, since it estimates the closeness of the "dots" of which they are composed.

Indeed, we may generalise the definition of A_o as the angular area which on being increased by a very little will cause the structure of the picture and its imperfections to become visible.

The "very little" mentioned is, mathematically speaking, too loose a term, but in practice there seems to be no need to define this further.

In the case of a painting A_o will be the size which just does not show up the individual brush strokes. Or in that of a cinema film where the flicker, blurring of the details, and

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scratches on the film just become invisible.

In these last cases the breadth and lengthways definition of the picture is the same, hence A_o is a complete measure of the ability of the pictures to reproduce objects visually. But in the case of television strip analysis we have to consider further the case of the lengthways definition of the strips composing the picture, since here there is no " grain " or structure to guide us.

A Measure of Efficiency.

It should be clearly understood that $A°$ is a measure of the efficiency of the whole picture, and is not a measure of the efficiency per linear unit of area; which latter quantity is given, of course, by dividing A_o by the area of the picture in the units chosen.

For example, suppose a printed photograph in a newspaper is 2 sq. ins. in linear area. On test we find its A_o equals about 0·0018. Now suppose the printer had employed the same screen (i.e. the same number of picture " dots " per inch), but had increased the linear size to 4 sq. ins. Then A_o will also double (to 0·0036) but the " clearness " per unit area, which the printer means when he speaks of the " sharpness " of the printed picture, will be the same. It will be 0·009 per square inch in terms of our special unit A_o.

Summing up this and the last section, we may state the following points. Because the tone of the length of the strips of the received picture is obviously dependent on the shape of the picture modulation, the quantitative estimation of this latter in terms of the band width occupied is also a quantitative measure for any given rate of scanning of the lengthways definition of the picture, i.e. its clearness along the length of the strips. The breadthways definition, or clearness, is measured by the breadth of the strips, for which there is an optimum value β. The area of maximum definition A_o is the picture size which gives this optimum value for the strip breadth.

So far, then, we have units of measurement for picture size, lengthways definition for a fixed rate of scanning, and for the size for the proper breadthways definition or clearness. This is shown diagrammatically in Fig. 5. The next section will deal with putting these together as equations.

Lengthways Analysis.

8. We have shown that if the strip breadth is equal to β, and there is no space between the strips, the breadthways analysis of the picture is perfect.

A telegraphed picture.
Photo by courtesy of "Daily Mail."

The next question is that of the lengthways analysis (i.e. the lengthways graduation of the strips) which is given by the shape of the picture modulation.

Now the band width of the latter is, as we have shown in the last section but one, proportional to the rate of scanning, that is to $\frac{L_s}{t}$

Where L_s is the length of strip scanned in a time t. Obviously L_s is proportional to A_o; hence we may state that—

$$\frac{A_o}{t_1 f_{max.1}} = R \quad \ldots (4)$$

where t_1 = the time of transmission of the picture.
$f_{max\,1}$ = the top frequency of the picture modulation.
A_{o1} = the area of maximum definition of the picture.
R = what we may term the "scanning ratio" for the system of transmission in use.

Finding Maximum Frequency.

It follows, by simple algebra, that if we wish to find, say, the top frequency $f_{max\,2}$ for the transmission of another picture having an area of maximum definition A_{o2} transmitted in a time t_2 we have—

$$f_{max\,2} = \frac{A_{o2}}{t_2 R} \quad \ldots (4{\cdot}1)$$

for the system having a scanning ratio R. This result is of the utmost importance.

Now, just as in the case of the breadthways analysis, where we do not require β (and therefore A_o) to be any smaller than will make the strips just invisible to the eye; we do not need to make the lengthways definition (along the length of the strips) give more details than will be apparent to the eye with the optimum value of A_o (that is, the breadth and lengthways definition should be equal). Now, the magnitude of the picture modulation band width is the measure of the lengthways definition, and we may expect to find a maximum value for it for a given A_o just as we found a *minimum* value for β (since this latter was inversely proportional to the breadthways efficiency of analysis).

This is actually the case, and its measurement will be treated in full in the next section.

Standard Scanning Ratio.

We can, then, get a standard scanning ratio R_o by substituting in

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equation (4), and by means of (4·1) find the top frequency for any time of transmission, of any picture of given area, *to get perfect clarity in both dimensions.*

But perhaps we may desire to depart from this standard to a greater or less degree. For instance, we may use a larger angular area of the picture instead of its area of maximum definition (i.e. we will substitute a new area A for A_{o1} in the equations (4) and (4·1), though this will not enable a normal audience to see more detail (see note on low acuity at end of section 4) or we may reduce the lengthways definition by reducing f_{max}, which will give blurred edges and general mistiness in this dimension, but will not show up the scanning lines.

The object of such a departure from perfect clearness would be to reduce f_{max}. The degree of imperfection of any system may be indicated by—

$$H=\left(\frac{f_{max_o}}{f_{max_1}}\right)-1 \quad \ldots \quad (5)$$

which will be termed the " tolerance " of this system.* Here—

f_{max_1} = the top frequency given by the new arrangement for given values of A and t.

f_{max_o} = the top frequency given by the standard scanning ratio R_o for A_o numerically equal to the above value of A, and for the same value of t.

The standard R_o may then be defined as the most efficient ratio between A_o and f_{max}.

Care should be taken that the angular area of a picture at any distance is not confused with the area of maximum definition because of the use of the same unit of measurement in both cases, that is, radians$_2$.

Latitude in Definition.

Judging by the annoyance caused to the audience in a cinema by a slight darkening of the screen we may expect that nothing short of televised pictures of standard scanning ratio, or nearly so, will satisfy the public in the future, but we may note that moving pictures have rather more latitude as regards the necessity for perfect sharpness than " still " ones.

In illustration of this it is well known to nature photographers that a still view of, say, an animal moving in grass may entirely fail to show it up, but a cinematograph record will cause it to stand out boldly, though the individual pictures may not be so clear as before.

And the addition of sound, too, helps the illusion.

Fig. 6.

An enlarged portion of the telegraphed picture shown on the previous page. In the original the strips were about 0.2 mm. broad, and β was found to be about 0.00065 to 0.0007 radian.

The area of maximum definition in the ordinary cinema theatre would appear to be not far from 0·05 rad.^{2}, as inferred in section 4, which again confirms the choice of this value for television.

From these equations and definitions it is possible to obtain quantitative expressions for any known system of picture transmission. A double stereoscopic picture will double f_{max}, and a three-colour image will increase it theoretically, though the extra realism given by these methods might probably allow a large value of A_o and hence also R_o in practice.

A Unit of Tolerance.

Summing up again, we now have a standard of efficiency R_o which shows the correct band width and picture rate for any picture size. If we wish to depart from this standard, as may easily be the case, we have a unit of tolerance just as in any other branch of engineering. By finding this for any system we have a unit of comparison. As an instance, it is merely necessary to know the band width f_{max} and picture rate $\frac{1}{t}$ of the system in question and the angular area of the picture size used (A). Then, from equation (4) we may find the standard band width for an area of maximum definition numerically equalling A. This will be f_{max_o} in equation (5) and from this, by inserting f_{max}, we may get the tolerance (H) of the system being examined.

Elaborations of the equations and different uses of the units may be employed if needed for special purposes.

Measurements and Numerical Results.

9. One of the most important uses of equations (4) and (4·1) is the co-relation they give between photo-telegraphy and television. Practically perfect results have been obtained for some time with the former, and we thus find both β, R_o and f_{max}, easily available for use as the standard.

The results with both the Bell and Siemans-Karolus photo-telegraphy systems, for instance, are very similar.

In the latter system the picture is scanned by a very small light spot. A photograph 9·5×6·7 inches area is transmitted in 20 minutes. A carrier wave of 1300 cycles is modulated by the picture current up to 650 cycles top frequency.* The observed value of A_o for this size was 0·44 rad.^{2}

The definition in both directions is the same, and therefore we have for R_o, the standard scanning ratio, from (4)—

* Another measure of H is $\left(\frac{R_o}{R}\right)-1$ where R is the scanning ratio of the system to be assessed. This is not so suitable for explaining the principle however.

* This data was obtained from " Picture Telegraphy," by E. S. Ritter in the Post Office E.E. Journal, Vol. xxi., Part 3 page 191, October, 1928, and from a telegraphed photograph and data very kindly supplied by the editor of the *Daily Mail*, to whom the writer's thanks are due.

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$$R_0 = \frac{\cdot 44}{1200 \times 650}$$

$$R_0 = 0{\cdot}564 \times 10^{-6}$$

β was found to be 0·00065 radian about, as indicated before.

is used at 450 r.p.m., giving about 7·5 pictures a second.

Judging from the published results* it is intended to be looked at from a distance of about 3 ft.

Tabulated Results.

System.	R	A	t	f_{max}	Tolerance H.
Photo-telegraphy (Standard; with area $=A_0$).	$0{\cdot}567 \times 10^{-6}$ $(=R_0)$	0·44 rad².	1200	650	—
		0·05 ,,	0·06	1,500,000	
		0·01 ,,	0·06	300,000	
		0·05 ,,	0·1	930,000	
Mr. Geloso (television).	$2{\cdot}6 \times 10^{-6}$	0·00173 ,,	0·133	5,000	3·7
		0·05 ,,	0·06	320,000	
		0·01 ,,	0·06	64,000	
Dr. Alexanderson (television)	$3{\cdot}75 \times 10^{-6}$	0·01 ,,	0·133	20,000	5·8
		0·05 ,,	0·06	220,000	
		0·01 ,,	0·06	44,000	

Note that $A_0 = 0{\cdot}00097$ rad.² in both the television systems.

We may take $R_0 = 0{\cdot}57 \times 10^{-6}$ for simplicity.

A portion of a telegraphed picture sent by this system, enlarged to show the strips of which it is composed, is reproduced in Fig. 6. It will be found interesting to demonstrate the principles given in this article by finding β and A_0 for this example.

The table shows the various values of f_{max}, given by various pictures sent at television rates. t equals the reciprocal of the picture rate per second.

Hence 0·06 second = 16·7 pictures a second,

And 0·133 second = 7·5 pictures a second.

Lack of Published Data.

Unfortunately, at the time of writing definite details of existing television systems are not available, and hence exact comparisons on the lines laid down are not possible. The author, however, ventures to hope that investigators may see their way to make actual measurements on their various devices and to publish the results.

Failing this more accurate data it will be of interest in the interim to examine some published television systems in the light of these principles.

Using a band width of only 5 k.c., Mr. Geloso has sent out from radio stations WRNY and W2XAL pictures about 1·5 ins. square. A 48-hole disc

$$A = \frac{1{\cdot}5}{36} \times \frac{1{\cdot}5}{36} = 0{\cdot}0017 \text{rad}^2.$$

when $R = 2{\cdot}6 \times 10^{-6}$

$H = 3{\cdot}7$

Note that $A_0 = 0{\cdot}00097$ rad.² (see section 7).

Unfortunately the band widths employed by Mr. Baird, in England, are not known to the author.

Dr. Alexanderson, in America, recently gave a public demonstration in a laboratory with a top frequency stated to be about 20 kc.† The transmission was of a man, shown full length, and included a boxing match. Teeth, tongue, and throat were visible in the man when seated, and the general definition was compared to that of the average amateur cinematograph. At a distance of ten feet from a foot-square screen the observers "could scarcely distinguish the scanning lines." The same 48-hole disc was used.

Then—

$$A = \cdot 1 \times \cdot 1 = 0{\cdot}01 \text{ rad.}^2$$

$$R = 3{\cdot}75 \times 10^{-6}$$

$$H = 5{\cdot}8.$$

The area of maximum definition is again only 0·00097 rad.², hence the large tolerance.

Before making comparisons it should be noted that these television figures are only deduced from published data, and are not from actual measurements. The following table shows the results at a glance. f_{max} is not given to more than two significant figures.

Of course it is quite possible, but scarcely necessary, to settle on a much more stringent standard than that of the photo-telegraphy systems considered. The final criterion is what the public will demand, and the reasons for not departing much from that standard have been given before. The next section will be found to give yet another.

Field of View.

10. For the television of large scenes, such as the Derby, the depth and breadth of the field of the "camera" in which the horses could be seen clearly, can be found as follows.

For simplicity a square screen is assumed, though the same principles can be applied to other shapes. First find the smallest area of maximum definition which will enclose the object to be seen—in this case a horse

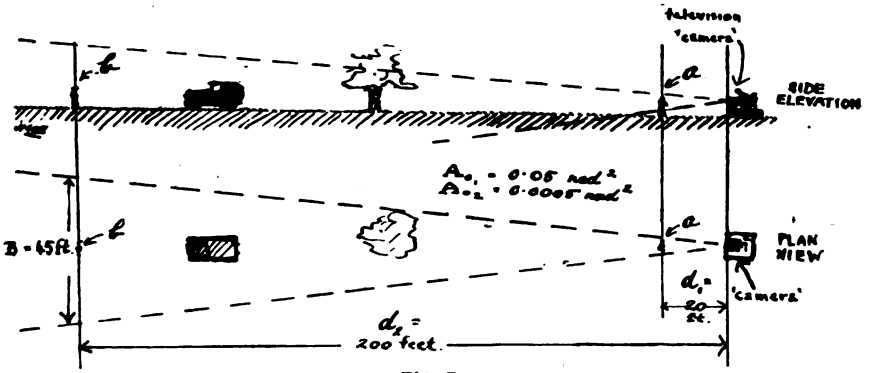

Fig. 7.
In illustration of the equations for fields of view. The side elevation and plan view of a televisor operating with the characteristics indicated. d_1 and d_2 refer respectively to the distances to the man at a and to the man at b.

* *Radio News*, page 411, November, 1928.
† *Ibid.*, page 527, December, 1928.

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and rider—and give as much detail as is desired. This may be easily done by moving away from a photographic or televised version of the object. Call this area A_{o2}; the area of maximum definition of the system of television employed A_{o1}; the linear height of A_{o2} designate by h_2; and that of A_{o1} by h_1.

then $$\frac{A_{o1}}{A_{o2}} = \frac{h_1^2}{h_2}$$

It is obvious from ordinary optics that—

where $$\frac{h_1}{h_2} = \frac{d_2}{d_1}$$

d_1=the linear distance of the object from the camera when it fills A_{o1} completely, i.e. fills the full field of view of the televisor.

d_2=the linear distance the object must be from the camera for it to fill A_{o2} (equals the depth of view of the system employed),

hence—

$$d_2 = \sqrt{\left(\frac{A_{o1}}{A_{o2}}\right)} d_1 \ldots (6)$$

And further, the angular breadth of the field of view will equal $\sqrt{A_{o1}}$ radians. From the definitions of the angle of maximum definition, and with the square screen specified—

$$\sqrt{A_{o1}} = \frac{b}{r}$$

using the same symbols as in section 2.

But $r=d_2$ and therefore b is the required breadth of view in linear units=B.

Hence—

$$B=\sqrt{(A^\circ_1)}d_2 \ldots (7)$$

As examples, suppose A_{o1}=0·05; A_{o2}=0·0005 and d_1=20 yards; then our depth of view will be, from equation (6)—

$$d_2=20\times\sqrt{\frac{0{\cdot}05}{0{\cdot}0005}}$$

$$d_2=200 \text{ yards.}$$

And from (7)—

$$B=\sqrt{(0{\cdot}05)}\times 200$$

$$B=45 \text{ yards.}$$

These results would, of course, have to be modified for a telephoto lens system. They are an excellent illustration of the quantitative results obtainable from the use of definite values for the "clearness" of a picture, and emphasise the fact that before we can televise a horse race the televisors must not merely be sensitive to the reflected light over the distance to the horses, but, further, the "grain" of the picture must be fine enough for the horses to be recognisable (i.e. A_{o1} must be large enough), which is equivalent to a small tolerance ratio H. They are also the basis of much of the technique of the television "camera-man" of the future.

In illustration of the foregoing, Fig. 7 shows a scene being televised.

King's College Centenary 1829—1929.

After one hundred years this College is appealing to industry for moneys to improve its science laboratories and to endow chairs in various faculties. The chair of physics requires £25,000. A succession of brilliant scholars have been at the head of this department.

The present professor of physics, E. V. Appleton, M.A., D.Sc., F.R.S., is recognised in this country and abroad as one of the foremost scientific workers in wireless research. A singular honour has been paid him by the American Institute of Radio Engineers. They have awarded him the Morris Liebmann Memorial Prize for 1929, for the most important contribution to wireless progress during the last twelve months.

Professor Appleton has, during the past five years, been conducting experiments for the Radio Research Board, on the influence of the upper atmosphere on wireless transmission. The work has included proof of the existence of the Heaviside Layer, and the first measurement of its height.

Communication with Belgian Colonies.

Another instance of the importance attached by European countries to direct wireless communication with their Colonies is the order just placed on the Marconi Company by the Société Belge Radioelectrique, on behalf of the Belgian Government, for a short-wave telegraph-telephone transmitter which will be used for communication between Belgium and the Belgian Congo and Belgium and South America.

Two short-wave receivers of the latest type, similar to those used in the Marconi beam stations, have also been ordered.

The Willis World-Time Indicator.

From J. H. Willis & Company, Ipswich Road, Norwich, we have received a most useful device known as "The Willis World-Time Indicator." This takes the form of a sheet of good quality cardboard measuring 7 inches by 8 inches. Lines marked in degrees of longitude radiate in all directions from a central point, and geographical areas and names of places are printed on the card in their proper positions according to longitude.

At the central point is fixed a little cardboard disc divided and numbered into 24 hours.

To find the time in any part of the world it is only necessary to turn the central disc until the time figure in the locality of the observer points towards the country in which he is situated. He then looks for the name of the part of the world in which he is interested, and the longitude line of that part of the world will then be found to intersect the central disc and give the correct time for that particular part of the world.

The central disc is also printed with light and dark sections indicating parts of the world which are experiencing day and those which are experiencing night.

The device should prove extremely useful to long distance broadcast listeners who want to find the correct Greenwich time at which to listen for a programme broadcast at any given time and in any part of the world. In these days of trans-oceanic and trans-continental telephone services it should also be extremely useful to users of such services, so that they may avoid calling up a friend at, say, 3 a.m. when they really want to talk to him at 3 *p.m.*! Those who travel in ships will also find the device extremely useful.

The only criticism of the device which we have to offer is that it is not provided with eyelets and string, so that it can be hung up in a convenient position.

To a London Friend.

Hullo! I'm in the U.S.A.
I only landed here to-day,
As I should like to see you soon
Please ring me up this afternoon—
You'll see me now? All right, that's that,
We'll have a televisored chat!

—*Leslie M. Oyler.*

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Sydney A. Moseley

ON

"THE FIRST TELEVISION BROADCAST"

AND so, after all, the first regular transmission of television in this country is to take place shortly. This article appears in the May issue of TELEVISION. If all goes well the first official broadcast may take place some time in July. Not bad going when you come to realise the tremendous amount of misunderstanding and mischief that had to be cleared up. The way, then, is clear for the big steady advance towards our goal.

"And what," you may well ask, "*is* our goal?"

The answer, obviously, should be the old adage: "Sufficient unto the day," etc.

Our first principle is accepted. That, for the moment, is the main thing.

"Television has arrived."

Even hard-boiled critics now admit this fact, some of them very cheerfully, I am glad to say. Indeed, the whole atmosphere is one of extreme friendliness, and altogether there is a desire to forget the past. To this attitude I, above all, am prepared to subscribe most heartily.

What First?

And now what about this first broadcast—what are listeners to see in the immediate future That is a natural question. Well, there will be a living image of the face and shoulders of well-known singers and speakers. The other day, for instance I saw Miriam Licette for the first time. I had admired her *voice* again and again, but I couldn't conceive what she was like. I had to go all the way, in bad weather as it happened, down to the People's Palace, Mile End Road, in order to satisfy my curiosity and admiration. In future, this will not be necessary. Had we had television her features would have been familiarised long ago. Needless to say, one ignores the photographs of celebrities that one sees in the press! After all, journalists are very kind souls, and—need I say more? In the case of Miriam Licette, however, I think her photograph barely did her justice.

What Next?

"And what of the future?" you may well ask. "Are we always to see the face and shoulders of those who broadcast? Is that to be the end as well as the beginning of television?" Captain Eckersley was asking me the other day something of the same sort. He wants to know what would happen at, say, the end of a year's broadcasting of television. Would the listener have to be content always with a head-and-shoulder view?

My reply was in the form of a question: "Would the listener of the ordinary broadcasting programme be satisfied to-day with what was offered to him when broadcasting first started?" Obviously not, nor should I expect the "Seer-in" to be satisfied after a year or so with merely a head and shoulder view.

But we have reason to believe that the development of television will be at least as rapid as that of sound broadcasting. I told Captain Eckersley of improvements and developments which have already taken place since he and his colleagues were given a demonstration at Long Acre. He was very interested, not to say surprised, when I told him that the Baird Company are already able to televise two, three, and four people together.

Recent Developments.

Indeed, in Mr. Baird's laboratory I have seen the first of a broadcast play as well as the first boxing match ever televised. True, these bigger events are still in the same stage of development as television was when I first saw it some months ago, but the period of waiting will not be so long as even some of the friends of television anticipate. With the facilities now available, developments ought to be astonishingly rapid.

The world's amateurs who have been waiting for the move that has now been taken by the authorities will step in and aid in the development of television in much the same way as they did when broadcasting first began.

When I made prognostications before they were received by some of

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my best friends with expressions of incredulity. They really thought, some of them, until quite recently, that I was having my leg badly pulled, and as for my reputation, well, the damage done to it was "irreparable." The Postmaster-General's letter, in fact, came as a thunderbolt to those people who had been fed on propaganda pap from foreign sources.

The editor of a certain wireless publication would not believe that it was possible to put over television by wireless. He actually told a friend of mine: "It is all very well doing it over a land line, but let them try and transmit without these lines."

That other people concurred in these sceptical views we know, but it seemed an extraordinary thing to hear from the lips of a wireless expert.

Prognostications.

At any rate, these prognostications of mine will now be received with a little more reverence. I repeat, therefore, that now broadcasting facilities are about to be given to the Baird Company we should see tremendous strides in the development of this fascinating science. I am willing to wager that before twelve months have passed we shall be seeing scenes inside the studio and from the outside as a matter of course.

I beg those readers who have taken part in the earlier fight not to relax their vigilance or interest. Big things will now happen, and if possible we shall be in for still bigger fights. So far as I am concerned, jubilant as I am over the success of my efforts in bringing my friends of the B.B.C. together with my television friends, I nevertheless expect intrigue and opposition from foreign sources.

Before this article goes to press, I am very much hoping that a big arrangement with a powerful Continental concern will fructify. This will be the result of rather prolonged negotiations, and although I am glad to think that this big merger has been brought off, I am better pleased that it is the home of the British inventor which has taken the first steps to express its official belief in Mr. Baird's great invention.

In thinking out these wonderful sciences, one must not regard them merely as mediums of further entertainment. I personally agree with those who think that the great broadcasting services of this country should be used for educational as well as entertainment purposes. It would be a great pity if such revelations as were given to mankind should be utilised merely to hear a comic singer or to see Mr. George Robey grimace.

Merlin Hall Aylesworth, President of the National Broadcasting Company of America, who is at present on a visit to Europe to study our broadcasting conditions.

Type of Programmes.

We are reaching a point when attention is to be given to the kind of broadcasting programmes to be put over by the Baird Television Co. Such influence as I possess will be thrown into the scales to make such transmissions worthy of the fight from which we are now emerging. Just as television messages are not to be used merely for communicating puns and limericks, so must television, in putting over figures and plays remember that it has a high mission in life. Let us have the fun by all means, but let it be a fair mixture between the highbrow and the lowbrow.

Incidentally, if any reader has any suggestions to make as to what the first television broadcast programme should consist of, I should be happy to receive these suggestions.

For myself, were I asked to suggest the first television programme, I might be inclined to draw up an all-Scotch programme out of deference to the Inventor!

Noctovision and Phonovision.

I presume that now television is well under way and developments are proceeding more or less along more normal lines, Mr. Baird will devote some of his attention to that equally interesting invention of his, "Noctovision." I gather that here the fight is not likely to be so lively. There are no other Richmonds in the field—as yet—and if there were it would make no matter; we should deal with them as we propose to deal with them in regard to television.

For those whose minds will run along the lighter grooves of life, there is "Phonovision." I understand that interesting strides have been made here, so that before long readers will have an opportunity of "looking in" and seeing those robust tenors, or the gentlemen from the Southern States of America who have left their mammies and roses behind. What a vista this "phonovision" should open up!

The Editor invites writers to send in suitable contributions to this Magazine.

MSS. should be typewritten (double spaced) and accompanied by a stamped addressed envelope for return, if unsuitable.

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THE FUTURE DEVELOPMENTS OF TELEVISION

By CECIL MALONE, M.P.

Mr. Cecil Malone is the Member of Parliament for Northampton. During the war he held various commands, and towards the close he was appointed first Air Representative on the Supreme War Council at Versailles. He was also Air Attaché at the British Embassy in Paris—being the first air attaché ever appointed to any Embassy. He also, in 1912, carried out the first experiments with wireless telegraphy from Naval Aircraft, and is one of the few Members of the House of Commons with scientific experience.

I AM very proud to have been the first Member of Parliament to raise the question of television in the House of Commons, and I am glad that as a result some of the preliminary difficulties have been overcome, and the satisfactory stage has been reached which is outlined by the letter of March 27th from the Postmaster-General to the Baird Television Company.

I have long been impressed by the marvellous and indeed revolutionary possibilities of the developments which the transmission of sight by wireless will bring to us. My first association with the broadcasting of pictures was in an experiment by the well-known scientist, Professor Fournier d'Albe, from 2 L.O., which was described in "Amateur Wireless" on June 9th, 1923. That was only the transmission of a still picture.

Subsequently, however, I assisted Professor d'Albe in an actual, albeit elementary, experiment in real television at the Royal Institution.

Now Mr. Baird has leapt ahead of all rivals, and in an incredibly short time has delivered the real goods. And Mr. Baird has made such strides since I first saw his experiments some twelve months ago to the time, last month, when by means of his apparatus I televised (is that the right word?) one of my colleagues in the House, Mr. Charles Ammon, M.P., that one might well say that he has improved his results out of all recognition—but perhaps in this instance it would be more accurate to say "into tangible recognition."

Mr. Baird's progress has given us a time factor. We have now some idea of how soon we may expect results. It shows us that the transmission of sight through the medium of broadcasting stations is an immediate possibility; and that the sooner experiments are carried out the sooner will it become a practicability as well as a possibility.

There are, however, many vested interests to be considered. We have in this country in the British Broadcasting Corporation, under the admirable management of Sir James Reith, and the very capable technical direction of Captain Eckersley, a broadcasting organisation more efficient, I believe, than any other broadcasting system in the world. Naturally many vested interests are bound up in such a great machine, and the changes necessary must, therefore, be worked out to cause as little injury to individuals as possible, provided that they do not stand in the way and retard development.

Then there are the outside interests to consider. There are the telegraph and cable companies and the newspapers. Television will mean the speeding up of the transmission of news and pictures almost beyond imagination. One foresees the householder reading his newspaper transmitted by television from the broadcasting station.

There is also the legal question. I doubt whether, in fact, the Postmaster-General has any statutory control over television, but the whole position is as yet quite undefined.

In the early stages of the negotiations with Mr. Baird, the Postmaster-General was quite rightly concerned lest the public should buy apparatus expecting results which were not yet possible. That period is, however, past.

I only wish that as much concern had been shown when "sound" broadcasting started, and the country was flooded with thousands of over-advertised "dud" receiving sets from firms, big and small, who made preposterous claims for their sets.

A difficulty has further been raised regarding the allocation of wavelengths for television, and the limited bands available make, I think, a policy of monopoly of broadcasting more essential. But it is the duty of whatever Government directs our destinies in the ensuing years to ensure that it is an enlightened monopoly.

I do not want to see the lusty young child throttled by jealous or frowsty foster parents.

What then is to be done? The immediate action required appears to me to be the allocation of a period daily for an experimental transmission such as has already been allocated for the transmission of still pictures, which I have always thought rather obsolete and futile. These experiments will lead to improvements in the apparatus, and should soon show the necessity for the allocation of a wave band or wave bands for continuous television transmission throughout the day.

Arrangements between the Baird Company and the Postmaster-General for the use of broadcasting stations do not present insuperable difficulties; and with the co-operation of that far-sighted genuis, Captain Eckersley, at the B.B.C., I am convinced that we shall see wonderful developments very shortly. Indeed, ten years ago anyone who had suggested the possibilities of television would have been registered as mentally defective.

What will be the effect of all this on the world?

Aviation, wireless, television could be great factors in breaking down barriers and bringing the nations of the world together.

We stand on the threshold of a new age, an age of new knowledge and new discoveries. The future—the day after to-morrow of time—is pregnant with vast possibilities. The giant strides made in science may either prove a blessing or a curse; but it is man alone who possesses the power to decide what the issue shall be.

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TELEVISION PROVES ITSELF

News of the Post Office Demonstration

By "ENGINEER."

NOW that the P.M.G. has issued his report on the television tests—a very satisfactory report too—one may say a little about those tests from the Post Office side. Up to the present, readers of TELEVISION have heard what happened at Savoy Hill, and how the transmissions were received on a private installation outside. The *one* receiving post, however, was in the heart of the General Post Office, at St. Martins-le-Grand.

There, in the secretarial department, two receivers were installed.

The room selected was a large conference and committee room, on the walls of which hung portraits of all the Postmasters that have ever been since the post first started, somewhere about the time of Henry VIII, and the various secretaries who have helped them. Together with these were numerous cartoons of past Postmasters, drawings and paintings of postmen and post coaches. Even the war found its representative there in the shape of a water-colour of the Islington postwoman, while the modern postman is well represented by an oil painting done by a London postman. Into the austere presence of this august company the engineers of the Baird Company were introduced and speedily considered ways and means. Outside aerials were not possible, so rubber-covered wire was hung lengthways from the picture rails, making aerials about 30 feet long. The earth was equally primitive, nothing more satisfactory than a radiator being available.

Two televisors, with the necessary battery equipment were installed—one a complete talker and seer, and the other a simple portable, without loud speaker.

To make sure everything was correct the B.B.C. music programmes were tuned in and put on the television screen. One could not, of course, see the performers, but when the televisors were properly adjusted the music created a pattern of wavy lines on the television screen, varying according to the loudness or otherwise of the music. When the proper test television transmission came through after midnight—the ordinary B.B.C. programme service preventing any transmission before—everything shown was immediately recognised at the Post Office; whether it was a box of matches, a cigarette, an engineer's tool, or a face.

As the time for the official demonstration drew near one could not help wondering what all the past Postmasters, whose faces looked so coldly and expressionlessly down from the walls would have thought of this new means of communication.

Frankly, under their unvarying gaze, it did not seem possible. However, time for such reflections was speedily cut short by the arrival of the official party.

One cannot give the names of those present, nor does it matter, but they were a truly representative group. A House of Commons in miniature.

At the precise time of starting the televisors were tuned in, and there on the screen of each of them appeared a face. The deputation, to judge by their remarks, were keenly interested and could scarcely believe the evidence of their own eyes.

It is Extraordinary.

In fact, one of them remarked to one of the engineers in charge of the apparatus: "I believe this is a swindle. You can't get it like this by wireless. Are you quite sure there is no trickery about it?" Being assured there was no trickery the same Member remarked a few moments later: "It is extraordinary. It is truly wonderful."

His surprise, however, was as nothing compared to that of the Baird staff when, at the end of the demonstration, the well-known features of Captain Eckersley appeared on the screen.

Everyone recognised him at once, even if he had not given the well-known test phrases of the B.B.C.'s early days.

Such a conclusion seemed to put the seal of friendship (the friendship of the B.B.C. with the new offshoot of broadcasting) on the demonstration.

Of all that august assembly, present either in the flesh or from the past, on canvas, probably no one was better qualified to judge the value of the new idea to the postal services than Sir Ambrose Fleming.

Without doubt this historic event will not be overlooked as television proves its value to mankind.

Television Broadcasts from Rome.

A correspondent in Malta informs us that experimental television broadcasts have recently been transmitted from Station IRO, Rome. These transmissions took place after regular programme hours on the usual broadcast wavelength.

The power of the station is 3KW. According to our correspondent, the announcer invited reports.

Further details are not at present available.

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HIGH TENSION CURRENT SUPPLY

Details for Eliminator Building

By W. C. FOX

In our April issue Mr. Fox discussed the pros and cons of H.T. batteries versus H.T. eliminators, and gave some preliminary information on the construction of an eliminator suitable for use by television experimenters. In the following article he gives full constructional details, together with a list of the actual components used.

IN building a mains unit to work off alternating current, the first thing to decide, as it controls everything else, is the output desired.

As a general rule it can be considered that from 100 to 150 volts will be dropped between the plate transformer output terminals and the final output terminals of the eliminator. These volts are dropped on the plates of the rectifying valve, in the choke, and through the smoothing condenser network. The valve should have a milliamp emission four times that required at the final output terminals. Here again some of the output is lost in the smoothing circuit, but not all, the remainder serving the very necessary purpose of safeguarding the valve from overloading and keeping up a steady supply of current on the choke and condensers so that there is no possibility of mains hum creeping through.

Transformer Requirements.

In the present case—an eliminator with an output of 300 volts at 40 milliamps—a transformer having a voltage of 550 across the secondary terminals, with an amperage of ·13, will be required, together with a valve capable of handling that voltage and with an emission of at least 160 milliamps. The filament requirements of the valve do not matter very much, as a transformer can be secured to supply it, and in any case the make of valve purchased will determine it.

Suitable transformers can be secured from the firm mentioned in connection with the battery charger described in a previous issue (January, 1929, issue, page 15), Messrs. F. C. Heayberd, 9, Talbot Court, E.C.3.

Almost any well-known firm of valve-makers can supply a suitable full-wave rectifying valve. A half-wave rectifying valve is scarcely suitable for any but very small outputs.

It is not proposed to give any details of transformer construction here, because it is assumed that an eliminator is wanted for other experimental work, and is not being constructed for the sake of the amusement that the work provides. Reasons for using two transformers, one for filament current to the valve and the other for the plate supply, have already been given, and although these might well be used by an enthusiastic amateur as reasons for building his own transformers, anyone who may be contemplating such a thing will be well advised not to attempt it unless he has special skilled knowledge.

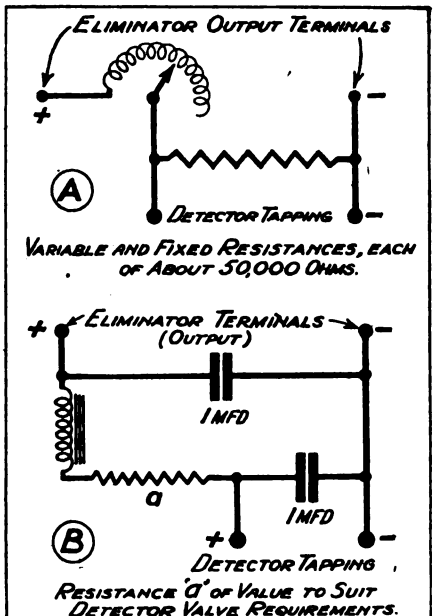

Fig. 1.
Arrangements which can be made to overcome "motor boating."

The windings run into some thousands of turns, insulation is an important matter, so is core design, while the whole job, if it is to be satisfactory, depends very largely on the skill and experience of the designer and maker in combining all these conflicting requirements into a harmonious whole. Most well-known makers have this skill and experience, and produce an instrument costing very little more than the necessary raw material as purchased by the amateur.

Amateur-built Transformers.

If, however, details of construction are required, these can easily be given in a later issue. One other point. The writer has heard of transformers built by amateurs, and fairly skilful ones at that, which on *no load* took over 200 watts, and speedily got so hot that one could fry bacon on them! Need more be said against home-made transformers?

Having decided on the total output required and selected the valve and transformers to meet this, the next point is the choke. In the set being described this is a general purpose one of 50 henries, with a carrying capacity of 100 milliamps. This has been found quite satisfactory, even when the eliminator was tried on a short-wave set.

Voltage Tappings.

The various voltage tappings are the next points to be fixed, and here it is essential to know, within reason,

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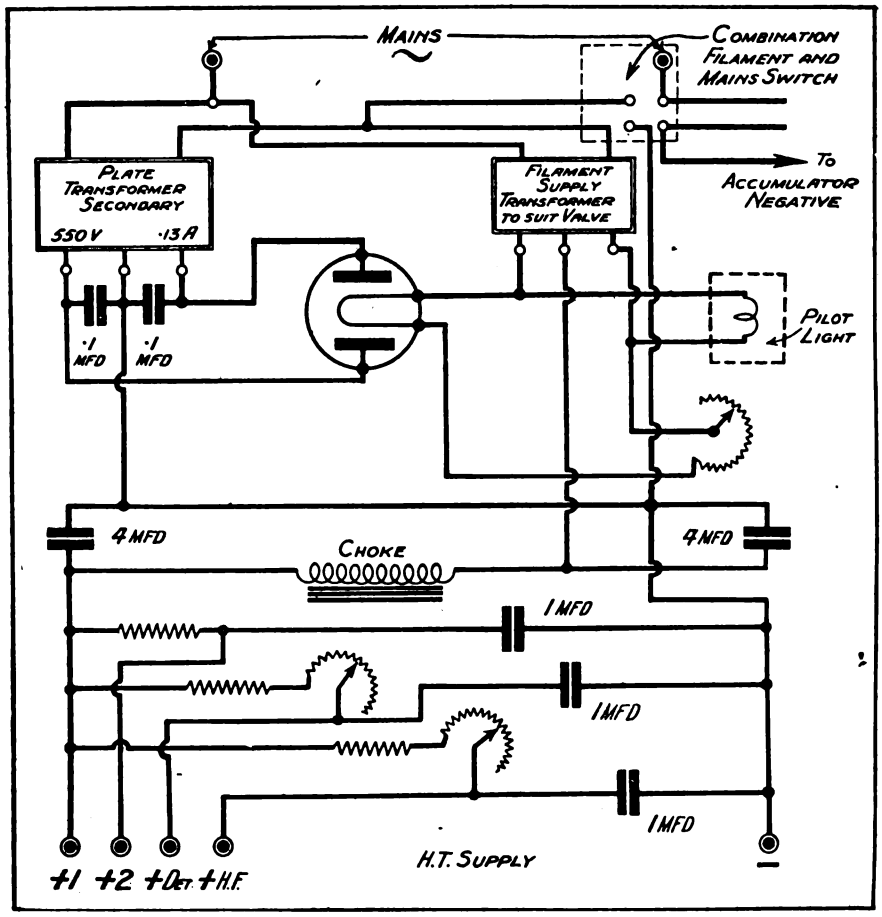


Fig. 2.

Schematic diagram of the eliminator. This layout can, if desired, be followed in the actual building, but for greater convenience the main combination switch and pilot light should be placed in front near the output points.

how many milliamps are required from each. Without this information the necessary calculations for the resistances cannot be made, although if expense is not a serious matter, each tapping point can be provided with an adjustable anode resistance followed by a Clarostat or similar finely variable high value resistance. Such a combination makes it possible to get quite low voltages of the order of 40 or so up to the full figure available.

In the present instance four tapping points are provided, one being the full output voltage, one a reduced voltage determined by a fixed resistance, while the remaining two are controlled initially by a fixed resistance with a variable resistance following for fine adjustments.

The resistances in use are 150,000 ohms for the first tapping point (which supplies an L.F. amplifying valve), 250,000 ohms for the detector (variable resistance following), and an adjustable resistance with a range from 32,000 to 500,000 ohms, followed by a variable resistance supplying an H.F. valve. This combination of resistances, after considerable experiment, has been found to be a very useful one, capable of giving a wide range of voltages at any of the three tapping points.

Avoiding "Motor Boating."

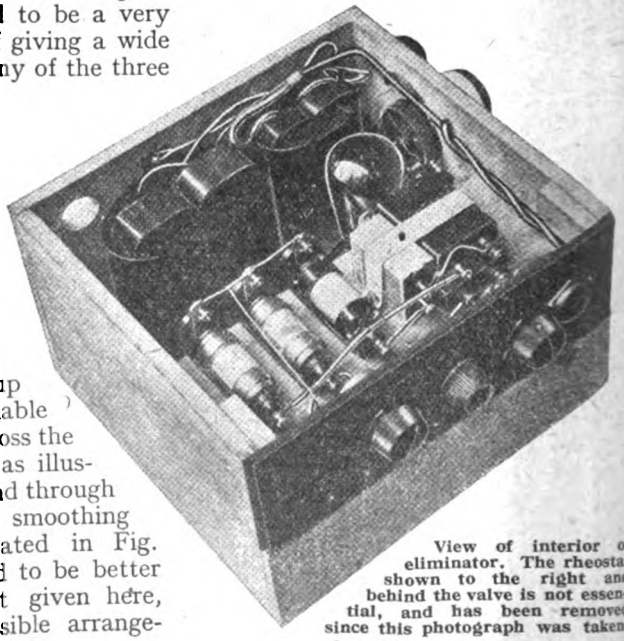
While on the question of tapping points it may be of interest to mention that the supply to the detector valve has been taken from a potentiometer arrangement made up of a fixed and a variable resistance in series across the full output terminals as illustrated in Fig. 1 (*a*); and through a separate choke and smoothing resistances as illustrated in Fig. 1 (*b*). Neither proved to be better than the arrangement given here, but as each is a possible arrangement to get over feed-back or "motor boating," they are mentioned in case anyone experiences that annoying trouble.

A full circuit diagram of the eliminator is given in Fig. 2. The small lamp shown being run off the filament transformer was an afterthought, added as a safety device.

The rectifying valve used is of the dull emitter class, and is so dull that one can scarcely tell whether it is switched on or not by looking at the filament. As part of the rectifier circuit carries 550 volts, and is capable of giving a very nasty shock, the small lamp (one of the pocket flash lamp class) was arranged to be fed off the filament supply to the rectifying valve, and placed behind a red window to act as a warning device. The window through which it shines, and its position inside the case, can be clearly seen on the right of the photos of the completed instrument. (See also photo on page 69 of the April issue of TELEVISION.)

Avoiding Shocks.

If the reader is very nervous of shocks, it is quite a simple matter to arrange a double-pole switch in connection with the lid of the case, so that the mere fact of raising it to get at "the works" automatically breaks the circuit. Don't forget, however, that there are condensers totalling about 12 mfds., all fully charged. These can give a very nasty shock, and they hold their charge for some hours at least.



View of interior of eliminator. The rheostat shown to the right and behind the valve is not essential, and has been removed since this photograph was taken.

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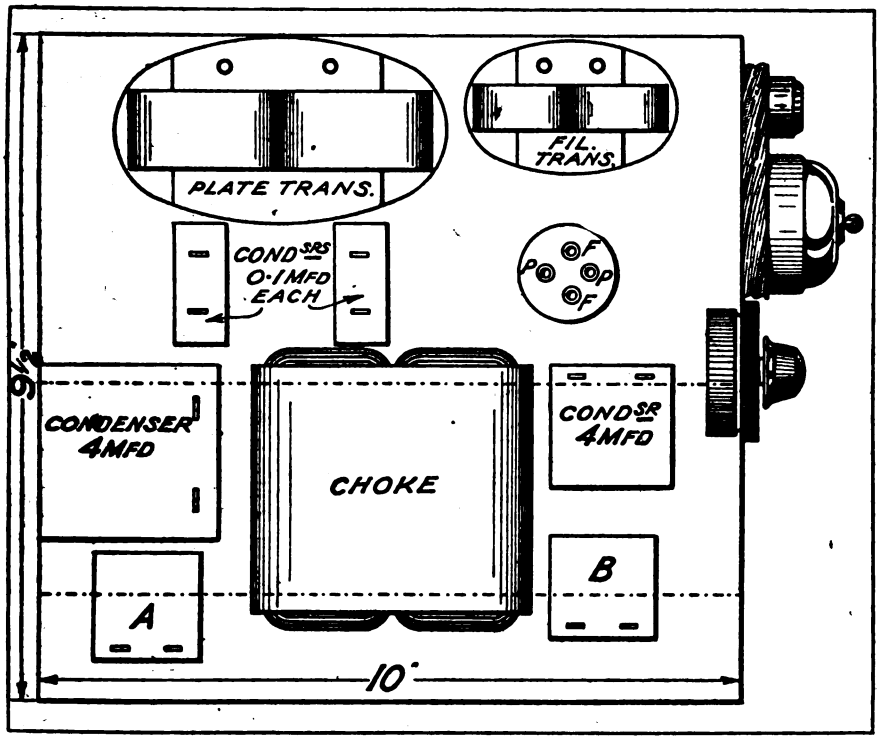

Fig. 3.

Baseboard layout of components. The dotted line running across the choke to the full width of the baseboard represents the bridge carrying the smoothing circuit resistances and condensers. A and B are condensers of 2 mfds. each, added across full output terminals.

If the reader wishes to safeguard the condensers from surge voltages due to the sudden switching off of the load, it is quite possible to do so by arranging a neon lamp in series with a suitable resistance across the full output terminals, so that it does not light until a voltage a little higher than the working voltage of the set is applied to it. Normally no current will flow, but when a rise of voltage occurs the neon will "strike" and speedily get rid of any surge.

Safety Measures.

The dangers of surge voltages can to a large extent be overcome by the use of a combined switch. Such a switch is manufactured by Messrs. A. F. Bulgin & Co. The knob by which it is worked can be seen next the red window in the illustrations. It automatically connects the negative of the filament accumulators to the negative of the eliminator during the first portion of its rotation; a further movement brings the filament current up to about half its value when the mains are switched on to the eliminator. The final movement of the switch brings the filament current up to its full strength.

The reverse process reduces the filament current, breaks the mains circuit, and then switches off the accumulators, leaving accumulator and mains eliminator circuits both "dead" and unconnected.

When the eliminator is to be used for a number of different purposes, where largely divergent supplies are needed, it is an advantage to have a variable resistance in the filament circuit of the rectifying valve. By reducing the filament current one can to a limited extent reduce the output of the eliminator. This resistance, however, should be capable of carrying two or three amps., as the current taken by most rectifying valves is fairly heavy.

Building the eliminator calls for no particular skill, provided one can use a soldering iron. Whether it is put in a metal box or not is largely a question for the constructor himself to decide. In any case, however, it is essential to earth the transformer cases, condenser cases, and the metal parts of any other components.

This can quite conveniently be done by running a bare wire from point to point, making sure that it is in electrical contact with each piece of apparatus. and is joined to the negative output terminal. In the case of a metal container, each component can be earthed to the container, which in its turn will be connected to the negative output terminal. All other wiring should be insulated, either with systoflex tubing or in some other way.

If space is limited things can quite well be packed together as closely as possible (the present unit is contained in a box measuring on the outside 10 ins. by 10½ ins. by 6½ ins. deep), but in any case ample provision must be made for ventilation. The transformers and the valve each generate a little heat which, if kept in a tightly closed box, is sure to give rise to trouble of one sort or another.

How tightly the packing of the components can be is clearly shown in the photographs of the interior.

The resistances and their condensers are carried on a bridge over the choke, while either side of it are the main smoothing condensers. Upright at the back are the two transformers with the valve in front.

A strip of ebonite can well be used to carry the control switch, the variable resistances, and the tapping points. With regard to the latter, completely shrouded terminals or a number of banana plugs and sockets should be used.

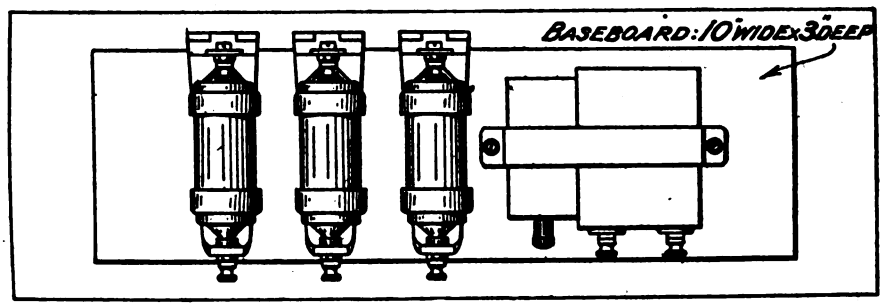

Fig. 4.

Layout of the smoothing circuit components on the bridge which is shown dotted in Fig. 3. Compare the two drawings on this page with the photographs.

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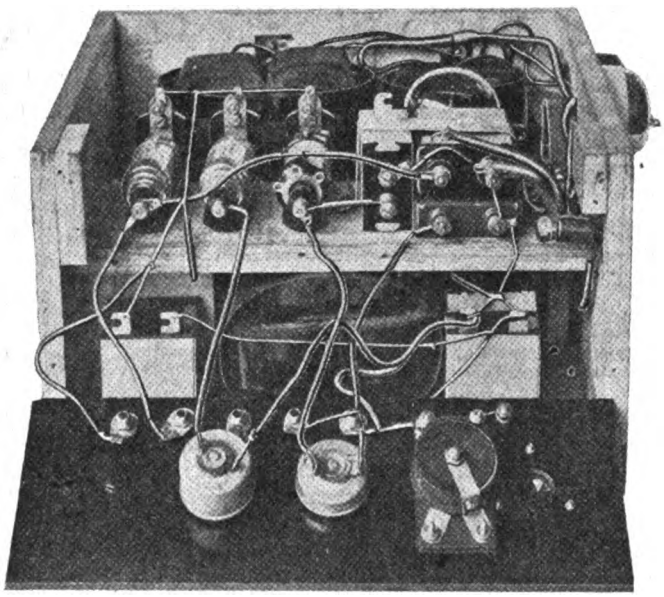
In any case, do *not* use bare terminals. Voltages at these points are high, and the chances of getting shocks when adjusting the voltages and using the eliminator are many.

Exact measurements and the positions of the components are given in the layout shown in Fig. 3, but if, other components are used (and there is no reason why other parts of equal quality should not be employed) the lay-out and measurements will require to be adjusted accordingly.

The present instrument started life laid out on a board about 2 ft. 6 ins. long. Gradually it has been folded up and folded up into its present compact form, but as between the two arrangements — the one as spread out and straggling as it could very well be, and the other, about the last word in compactness—there is nothing in the working and efficiency to indicate any difference.

For convenience the unit is fitted with a plug and a tumbler switch to the mains supply in addition to the rotary switch which is normally used in working the set.

On the other hand, a long length of flex permanently connected to the transformer primaries, and terminating in a socket to fit the ordinary domestic lamp-holder, would be just as efficient a method of connecting to the mains. Special fuses have not been considered necessary, as the total call of the eliminator on the mains does not exceed 90 watts.



Interior of eliminator with front panel removed, showing clearly the disposition of the components and wiring. The bridge carrying the smoothing circuit is also clearly shown. The ebonite panel measures 10¼ in. by 3¼ in. The knob centres are 3¼ in., 5¼ in., and 7¼ in. from the left. Window centre is 1¼ in. from the right-hand side—all on centre line of panel. The socket holes are all on a line ⅝ in. from the bottom of the panel.

List of Components Used.

Transformer to Supply Plate Current.—Transformer "Supercision" G.P. 550 (Messrs. Heayberd) for use on 240 volts 50-cycle alternating current mains. Secondary output 550 volts at ·13 amps. Secondary winding centre tapped. Voltage for each half of winding 275 volts.

Transformer for Filament of Rectifying Valve.—Transformer "Supercision" (Messrs. Heayberd) for same mains current as above, to light filaments of rectifying valve. Centre tapped secondary. Full output 2·5 volts at 3 amps. Rectifying valve. Telefunken R.G. N1503 filament current 2·5 volts at 1·4 amps. Plate current, 2 plates, at 300 volts each with 150 milliamps each. *Note.*—These are maximum figures.

Condensers.—Two hydra, 500 volts A.C. tested, ·1 mfd. each.

Condensers.—Two hydra (mica), 500 volts A.C. tested, 4 mfd. each.

Choke.—1 "Supercision" (Messrs. Heayberd), 50 henries, carrying capacity 100 milliamps.

Voltage Dropping Resistances.—2. R. I. Varley annode resistances and holders suitable for voltages required. (Values as given in text.)

Variable Voltage Dropping Resistance.—1. R. I. Varley adjustable rheostat and holder.

Clarostat Resistances, adjustable carbon compression type.—2.

Condensers.—3, 1 mfd. each, any well-known make, 500 volts D.C. tested for secondary smoothing circuit.

Main Operating Switch.—1, Bulgin combined H.T. and L.T. switch.

Rectifying Valve Filament Rheostat.—1, "Royalty," 5 ohms to carry 3 amps.

Pilot Light.—1, pocket flash lamp, 3 volts, and screw-holder.

Red Window for above.—1, Bulgin.

Condensers.—2, Mansbridge type, 4 mfd. each, across final output.

For Mains Connection.—1 tumbler switch, 1 two-pin plug and socket.

Lengths of wire and flex, screws, timber, piece of ebonite, banana plugs and sockets, etc.

This list of parts is given simply for the amateur who fears to launch out for himself. To help the same class of constructor the following simple examples of how to calculate the value of the various voltage dropping resistances are given.

Total output of the eliminator, 300 volts.

Voltage of 150 at 1 milliamp required at first tapping point.

According to the well-known formula, volts to be dropped=amperes × resistance in ohms.—this gives us the formula :—

$$150 = \cdot001 \times X$$

$$\text{or } \frac{150}{\cdot001} = 150{,}000 \text{ ohms.}$$

A further example: Voltage required 80, at 3 milliamperes.

80 from 300 leaves 220, the volts that it is required to drop.

This gives the formula :

$$220 = \cdot003 \times X$$

$$\text{or } \frac{220}{\cdot003} = R.$$

This brought to whole numbers, because milliamps are only 1/1000th of an ampere, gives us :

$$R = \frac{220{,}000}{3}$$

which on working out comes to

73,333·33· ohms.

A resistance of 80,000 ohms, a commercial size, will be suitable in this case, or if one adds a little extra for safety's sake, 100,000 ohms will be suitable.

The list of parts actually used in this elimination are given for the benefit of those constructors who might wish to follow as closely as possible the original. There is one point however which, without outside aid, they could not follow. As far as the writer knows, Telefunken valves are not purchasable in this country, although quite common abroad.

An Alternative Valve.

An alternative valve, and a very good one too, which is quite suitable, is the Ediswan type H.U. 235 full-wave rectifier. This valve will handle considerably more power than the transformer can supply, and it is therefore advisable to turn the filament rheostat down a little and so limit its output.

There is, too, an advantage in using it, for when working it gives a violet-blue glow which makes it unnecessary for one to have the pilot light and red window as a warning that the mains are switched on.

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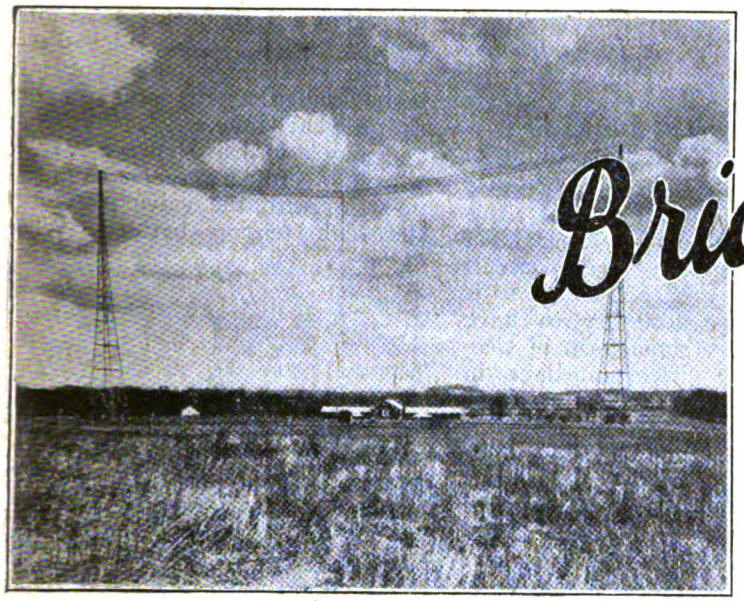

Bridging Space

by

JOHN. WISEMAN

Part XI.—AMPLIFICATION

As mentioned near the end of last month's article, we shall devote the remainder of this series to a simple consideration of how amplification is effected in any wireless receiver, for we have satisfactorily disposed of the questions of modulation and rectification. From past experience I find that nearly all users of wireless sets encounter difficulty in comprehending how they can get more power out of their set than is actually put into it and are puzzled to know from whence this extra energy is derived.

We have shown that the actual voltages induced in the receiving aerial are very minute, so in what way does the set function to allow, say, a cone or moving coil loudspeaker, or the Neon lamp of the televisor, to be successfully operated. The small rectified voltages from the aerial direct are obviously far short of requirements in this direction.

Let us refer to the simple circuit of Fig. 1, which gives the bare essentials of any high frequency amplifying stage, since we shall deal initially with high frequency working —that is, amplification before rectification. The diagram indicates that there is some form of circuit marked input which will allow energy either from the aerial or a preceding valve to be fed between the grid of the valve and the filament. In the plate circuit, and in series with the high tension battery, is an output circuit, and if amplification is to take place we shall here expect to find magnified impulses as compared with those across the extremities of the input circuit.

What to Avoid.

It should be fairly obvious that, other things being equal, the larger we can make the voltage variation introduced between grid and filament the larger should be the amplified impulse measured across

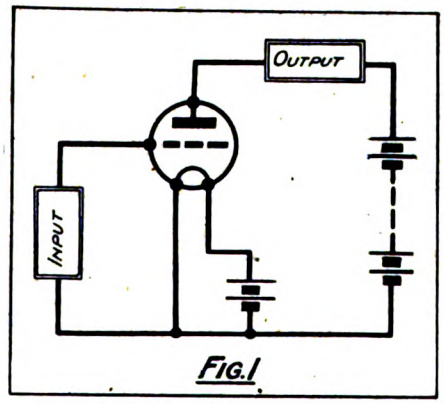

FIG. 1

The bare essentials of any amplifying stage.

the output circuit. That is one reason why we tune the grid circuit, for we have learnt from previous articles in this series that we can thereby get the largest response to the particular frequency (and of course wavelength) which we are desirious of receiving and amplifying.

Our first step in the amplifier stage, therefore, is to tune the grid circuit by placing a coil and variable condenser in parallel between the grid and filament. In order to overcome any loss of energy at this point it is essential to choose components of the highest grade, and hence the popularising of " low loss " coils and efficient variable condensers. Any form of energy leakage in this tuned circuit brought about by poor insulation, unwanted capacity or coupling effects, will reduce the amount of useful energy which is handed on to the grid of the valve, so this must be avoided at all costs.

Valve Amplifications.

Before turning to the plate circuit, consider for a moment what is happening inside the valve. We have already studied its working in a simple manner, but by turning to Fig. 2 we should be able to trace how amplification is brought about. Let the point *X* represent the steady working condition for the valve of Fig. 1 on its characteristic curve (see Part V.) *BE*. This actual point will depend upon the plate and grid voltages chosen, but when no oscillation of any kind is imparted to the grid then *XH* represents the steady plate current.

Now assume that an incoming signal causes a voltage change on the grid such as is shown by the sinusoidal curve below the base line. This will change the valve plate current over a length represented by *YZ* on the curve. To put this change into figures we will say that the total plate current change is one milliampere, this being effected by a

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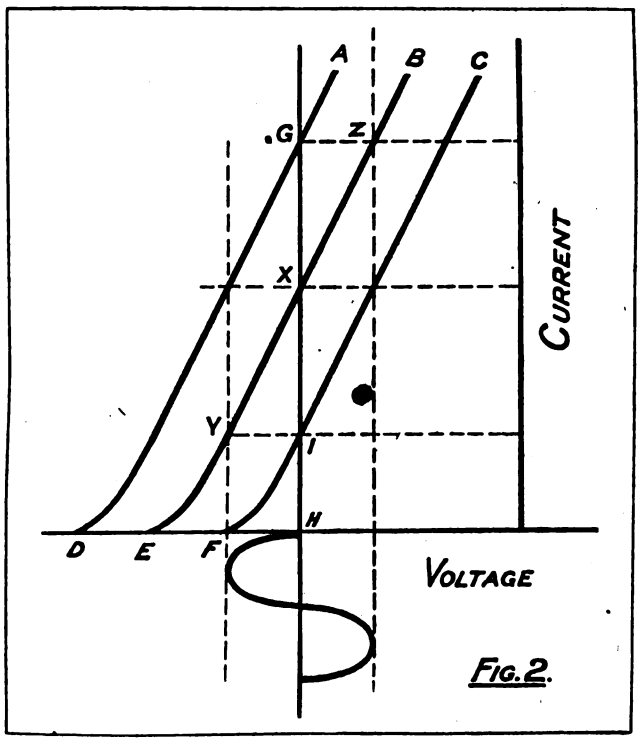
4-volt grid change, that is, 2 volts above and 2 volts below the steady working position. Now, to bring about the same change of plate current through an alteration of



Typical valve characteristic curves, which help towards an understanding of how amplification takes place.

plate voltage when the grid volts are steady, we can see from the curves that this would mean changing from the point *I* on the characteristic curve *CF* to the point *G* on the characteristic curve *AD*.

The Amplification Factor.

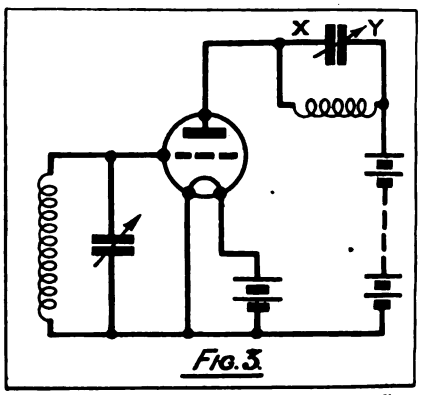
An examination of any family of characteristic curves for a valve (such as can be seen on the paper slip in a valve carton) will show the reader that to change from one characteristic to another in the manner indicated can only be brought about by a relatively large increase in plate volts, let us say in our case by 40 volts. We therefore have an interesting case of a 4-volt change on the valve grid producing the same alteration of plate current as a 40-volt change on the valve plate, or in other words, by working our valve through the medium of its control grid we get an amplification effect of 40 divided by 4—that is, 10—and this is commonly called the amplification factor. This indicates how the valve in itself brings about amplification, and is a point which should be thoroughly understood by the reader. The actual additional power is derived from the high tension battery.

Resisting Current Change.

Now, when we bring about this current change in the plate circuit of our valve it is necessary to have some form of electrical impedance in that circuit so that the resultant voltage change can be passed on from this impedance to the next valve. Put into concrete terms, we say that the function of the plate impedance is to resist changes of anode current and thus make any signal at the grid reproduce itself in the form of the largest obtainable fluctuation of anode potential.

If we include any ordinary resistance, this will, in addition, resist the flow of our steady current, and with large values of resistance the plate battery has frequently to be of a very high voltage. Since, however, the effects are alternating in character and of high frequency, some form of inductive circuit with a low direct current resistance would appear to be best suited, and in actual practice this is what is done.

A simple form is shown in Fig. 3, where an ordinary tuned circuit is in series with the valve plate and the high tension battery. When

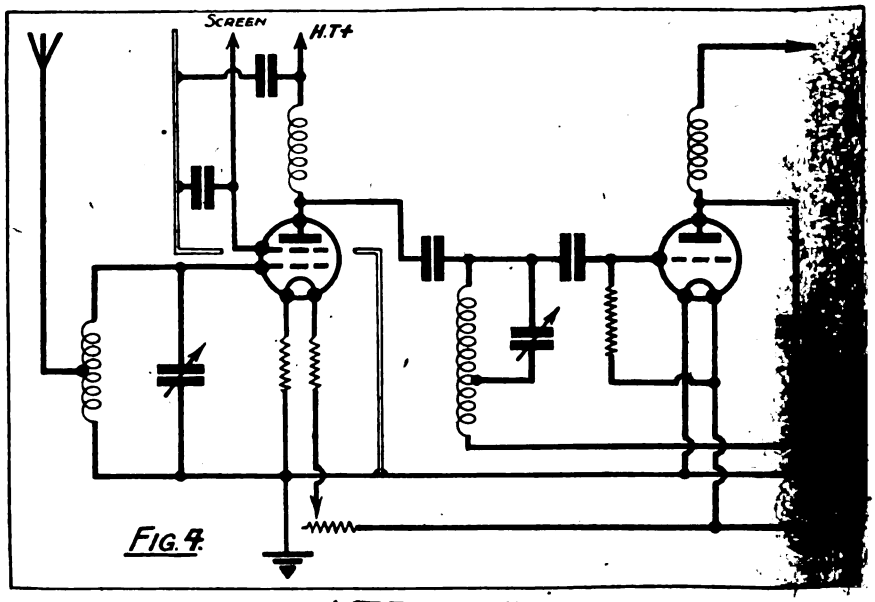


A simple tuned circuit, employed as a coupling device to pass on amplified energy to the output circuit.

tuned to any particular frequency there is a high impedance between the points *X* and *Y*, and in consequence a large voltage change across them, and this can be fed to the grid of a succeeding valve by means of a coil coupled magnetically to the tuned coil, or through the medium of a fixed condenser.

Unwanted Oscillations.

Actual circuit details do not concern us at the moment, merely



A CIRCUIT TO TRY.
A circuit recommended by the writer for H.F. amplification. One of the new screened grid valves is used.

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operating principles ; and it is desirable to point out where difficulties are likely to arise. With the advent of more efficient valves and components it was found that high frequency amplifiers exhibited a tendency to oscillate or to be unstable in operation. We know that to increase signal strength in a wireless receiver reaction in some form or another is artificially introduced, but the spurious oscillation which is so often met with in high frequency amplification is due to other causes. Without going into detail, suffice to say that for oscillations to occur there must be some form of coupling present which will enable energy to be fed back from the plate to the grid circuit. As a rule, this parasitic effect is attributable to three main causes, namely, conductive, magnetic and capacitative coupling.

Three Main Causes.

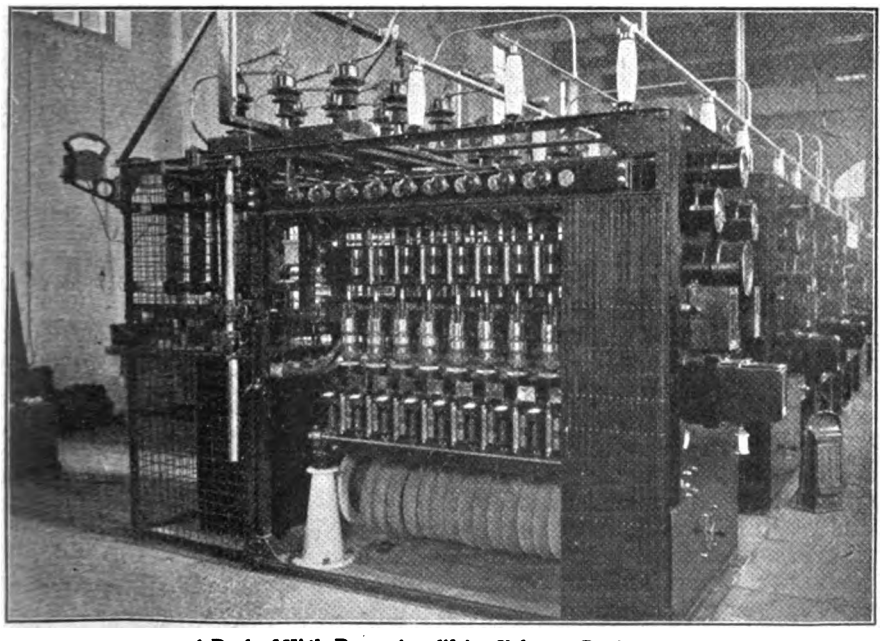
The first-named is primarily the outcome of high resistance batteries or long connecting leads and calls for a rigid observance of layout, "short path," wiring, anode feed devices, etc. In the case of magnetic coupling the trouble is usually avoided by using fieldless coils or metallic shielding, but when we come to capacitative coupling the problem cannot be dismissed so easily. In the majority of cases it is due to the stray capacities existing between the valve electrodes themselves, especially that between the plate and grid.

Cures have been effected by what is termed neutralising or balancing out the capacity feed back by equal and opposite effects, while more recently we have seen the development of the screened grid valve which gives very high and stable amplification, provided certain simple precautions are adopted.

A Circuit to Try.

To attempt to deal with the many forms of high frequency amplifiers and their operation would be entirely out of the question in an article of this length, but undoubtedly the advent of the screened grid valve has placed in the hands of wireless enthusiasts a solution to their problems of getting efficient results. Many circuit details have been published by valve makers and in ordinary wireless journals, but one circuit which I have found particularly efficient is that shown in Fig. 4, details of the high frequency valve and detector valve only being shown.

The filament resistances in the high frequency valve are for the purpose of giving a negative bias to the grid and also to allow a 2-volt valve to be used in conjunction with 6-volt valves in the other stages of the receiver. Capacity reaction is included in the detector stage, while the high frequency valve is provided with a metallic screen across its shielding grid. Perhaps at a later date it will be possible to give complete receiver details of a set based on these lines, but at the moment this does not fall within the purview of "Bridging Space."



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The Postmaster-General's Decision

[Below we reprint from "The Times" of March 28th the full text of the Postmaster-General's letter to the Baird Television Development Company, embodying the decisions which he arrived at after witnessing the official test of television which we reported in our last issue.]

SIR,—The Postmaster-General has considered the results of the recent television demonstration, in conjunction with the British Broadcasting Corporation and his technical advisers, and he has reached the following conclusions, which accord generally with the opinions of those who witnessed the demonstration. The demonstration showed that the Baird system was capable on that occasion of producing with sufficient clearness to be recognised the features and movements of persons posed for the purpose at the transmitting point. It is not at present practicable to reproduce simultaneously more than perhaps two or three individuals or to exhibit any scene or performance which cannot be staged within a space of a few feet in very close proximity to the transmitting apparatus.

In the Postmaster-General's opinion the system represents a noteworthy scientific achievement; but he does not consider that at the present stage of development television could be included in the broadcasting programmes within the broadcasting hours. He bases this view not so much upon the quality of the reproduction which further experiments may be expected to improve as upon the present limited scope of the objects which can be reproduced.

The Postmaster-General is, however, anxious that facilities should be afforded, so far as is practicable without impairing the broadcasting service, for continued and progressive experiments with the Baird apparatus, and he would assent to a station of the British Broadcasting Corporation being utilised for this purpose outside broadcasting hours. He understands that the Corporation would agree in principle to this course, provided satisfactory terms were negotiated between the Corporation and the Baird Company.

It will probably be essential that any experimental demonstrations of television should be accompanied by the broadcasting of speech, and in consequence two wavelengths and two transmitters would be required. It will not be possible to provide a second transmitter in a suitable locality which will avoid interference with important wireless services in Central London until the completion of the new station of the British Broadcasting Corporation at Brookman's Park, which is expected to be ready in July. In the meantime, it is suggested that the company should open negotiations with the Corporation as to the financial and other arrangements which may be necessary, and it would probably be advantageous to them to enter upon discussions of the technical aspect with the Corporation's Chief Engineer.

In order to find room for a television service in broadcasting hours, it will probably be necessary to utilise for the reproduction of vision wavelengths outside the bands now being used for speech broadcasting. These bands, as you are doubtless aware, are already highly congested, and it is important, therefore, that the company should press on with experiments on a much lower band, which will be notified to you in due course.

In conclusion, it is necessary to emphasise that in granting facilities for experimental demonstrations in which the public can if they so desire take part, neither the Postmaster-General nor the British Broadcasting Corporation accept any responsibility for the quality of the transmission or for the results obtained. The object of the demonstration is to afford the Baird Company a wider opportunity than they at present possess for developing the possibilities of their system of television and for extending the scope and improving the quality of the reproductions. While the company will not be precluded from selling apparatus to anyone who desires to purchase it, the purchaser must understand that he buys at his own risk at a time when the system has not reached a sufficiently advanced stage to warrant its occupying a place in the broadcasting programmes.

I am, Sir,
Your obedient Servant,
G. E. P. MURRAY.

General Post Office,
March 27th, 1929.

Short Wave Broadcasting Transmitter for Italy.

The Italian Broadcasting Company has authorised the Marconi Company to proceed with the manufacture of a short-wave broadcasting transmitter for Italy.

The Marconi Company has had considerable experience in the technique of short-wave broadcasting through the operation of the short-wave station (5SW) at Chelmsford. The Italian station will to a large extent follow the design of 5SW, and will enable the Italian Broadcasting Company to carry on a broadcasting service for the Italian Colonies.

Italy will thus be one of the first countries to make special provision for its Colonies in its broadcasting organisation.

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The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

Part V.—The BIRTH of the TELEPHONE

CHARLES WHEATSTONE, of England, whom we have already mentioned as one of the greatest of telegraph pioneers, was probably the first man to grope for telephony. At the age of nineteen he invented "the enchanted lyre," which was really a stringed instrument connected to a musical box by a long rod. The instrument was set in vibration by the rod connection to the musical box, and as both the rod and box were hidden from view the device was christened "the enchanted lyre," and was well known in London in 1821. Wheatstone undoubtedly saw the possibility of communicating speech, and even dabbled with a microphone, but he was too far off the track, and telegraphy soon claimed him for its own.

The Pioneers.

The whole idea of telephony lay dormant for nearly forty years, until Phillip Reis, a German electrician, produced a telephone for the transmission of sound. As a matter of fact, Charles Bourseul, a Frenchman, had hit on much the same idea a few years before, but Reis knew nothing of that, and Bourseul had made no attempt to put his idea into practical form.

Reis's transmitter consisted, quite appropriately, of the hollowed-out bung of a beer barrel with the skin of a sausage as the diaphragm. A piece of platinum was fixed to the sausage skin in such a way as to make and break an electric current when the skin was set in vibration by a sound. The receiver consisted of a knitting needle on a sounding board, with a coil of wire round the needle. The interrupted current from the line passed through the coil and set the needle and board in vibration, by which means a sound was produced similar to that made at the sending end.

Inarticulate Noises.

Reis could transmit noises, vowel sounds, and, to a certain extent, music, but he could not reproduce articulate speech. In Germany he is often claimed as the inventor of the telephone, but in other countries the invention of the telephone is invariably linked with the name of Alexander Graham Bell, of Scotland, that land of pioneers.

But as we have found before in considering the birth of other electrical communications, the picture is never complete without a dash of American genius, and we must not pass on now without mentioning the names of two Americans, Royal House and Elisha Gray.

House, before Bell, had patented an electro-phonetic telegraph, capable of operating as a telephone in just the same way as Bell's apparatus; but he never realised the possibilities of his invention—a case like that of Hughes, in wireless, as we shall see later on.

Elisha Gray filed specifications of a telephone on the very same day as Bell, but a few hours later. He brought an action in the courts, but Bell's prior rights were sustained by the Supreme Court; and Gray, though he eventually took out some fifty patents, was completely overshadowed by the Scotsman. Gray's telephone was precisely similar to Bell's, except that he used a constant current to augment the current produced by the vibrating membrane, in much the same way as Edison did later, when he converted Bell's telephone to the form used at the present time.

Bell's father was a great pioneer of lip-reading. His absorbing passion was to bring science to the aid of the deaf, and this passion he passed on to his son, Alexander, who assisted him in his work in Edinburgh. But as at the age of twenty-four the son was threatened with consumption, of which two of his brothers had died, his father took him to America, and it was there that Alexander Graham Bell carried out his great pioneer work on the telephone. His first work was as an instructor of his father's lip-reading system, and it was then that he met Thomas Sanders, whose son was deaf, and Gardner Hubbard, whose daughter was deaf. Bell was so successful with his pupils, in more ways than one as he afterwards married Miss Hubbard, that Sanders and Hubbard combined to help him financially with his experiments; for Bell was rich in that pioneer's attribute, which we have dwelt on before—lack of money.

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Bell meets Watson.

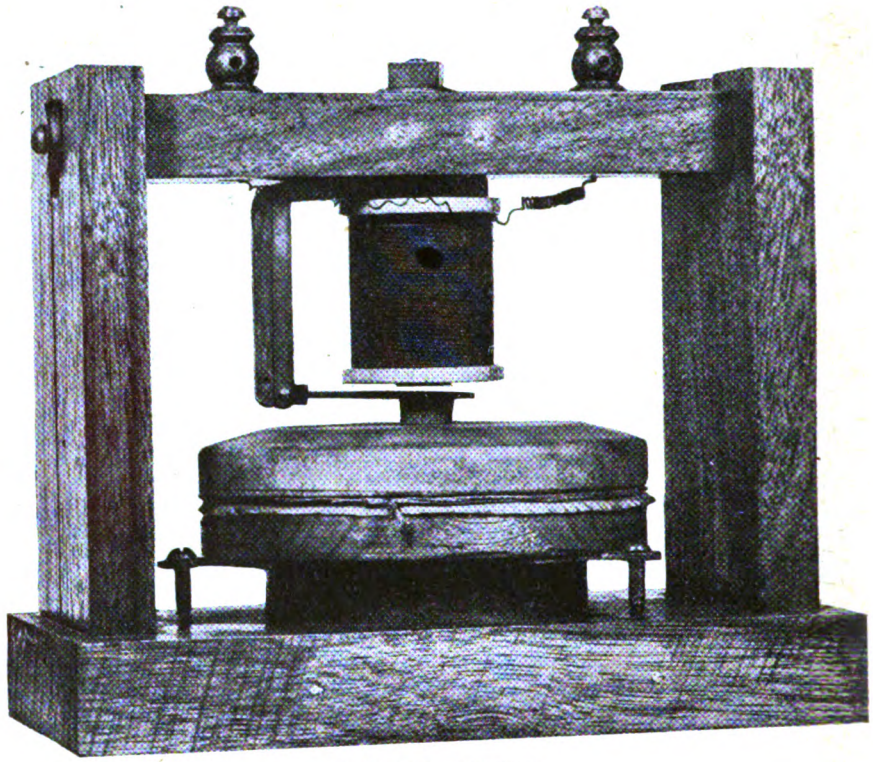
Bell's friends all laughed at his idea of speaking over wires, and prospects looked very black indeed until, in 1874, at Boston, he met Thomas Watson, a young American electrician. Watson, now Doctor Watson, is happily still with us, and gave a lecture in London only last year.

It is not too much to say that, without the assistance of Watson, it is more than likely that Bell's great idea of a speaking telephone would have fructified too late. Indeed it would be as difficult to think of Sherlock Holmes alone as of Bell without his Watson. When first they met, Bell had the idea of a "harmonic telegraph," and took his idea to an electrical workshop where Watson was employed. Watson took on the job, and from that moment the two men were seldom separated by more than a few yards of wire until the telephone had been demonstrated as a practical method of speaking over great distances. In trying to perfect their harmonic telegraph, Bell, who had never let go of the possibility of conveying speech, stumbled up against the principle of the telephone during some tests which they were carrying out, and on that very day Watson constructed the world's first telephone.

Most Valuable Patent.

These two pioneers worked day and night on their experiments, and on Bell's twenty-ninth birthday, March 3rd, 1875, he was granted "the most valuable single patent ever issued," a patent which gave rise to some 600 lawsuits.

A Telephone Operator at work in a London Exchange.



Bell's first Telephone.

A year later, at Boston, on March 10th, 1876, a seven-word message made history. For the first time a human voice came clearly over a wire. The voice was Bell's, and the famous message is again reminiscent of Sherlock Holmes: "Mr. Watson, come here, I want you."

The harmonic telegraph was then dropped, and as a matter of fact was afterwards perfected by Elisha Gray.

Bell's Telephone.

In Bell's telephone the disc which was vibrated by the voice did not, like Reis's, break the electric current, but by cutting magnetic lines of force produced currents in the coil of wire round the magnet. These currents flowed along the wire to the receiver, where the process was reversed, *i.e.* the currents flowed through the coils of an electro-magnet, thus varying the magnetisation, and so moving the receiving disc in synchronism with the transmitting disc. In this way the sound waves at the sending end were reproduced at the receiving end without the use of a battery, as was required by Reis, and as was introduced in later developments of Bell's apparatus.

In the year 1876 Bell showed his apparatus in an exhibition at Philadelphia. William Thompson, the great cable pioneer, saw it there, and reported that "this, perhaps the greatest marvel achieved by electric telegraph, has been obtained by appliances of quite a homespun and rudimentary character." Watson did not mind "the rudimentary character," but says that he has never quite recovered from the "homespun"!

Another great electrician, Moses Farmer, of America, saw the apparatus about this time, and Dr. Watson quotes him as saying: "If Bell had known anything about electricity he would never have invented the telephone." How often have we noticed in electrical communications that the pioneers have been led by an "amateur"? But it is not all jam. To quote Dr. Watson again: "Is it any wonder that my memory of those two years seems like a combination of the Balkan War, the rush hours on the subway and a panic on the stock market?"

It was not, however, what Thompson thought that impressed the public;

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it was what Dom Pedro, the Emperor of Brazil, said when he tested Bell's telephone at the exhibition: "My God, it speaks!" was all he said; but it was enough to tickle the public imagination and to broadcast all over the world the name of Alexander Graham Bell.

The First Telephone Company.

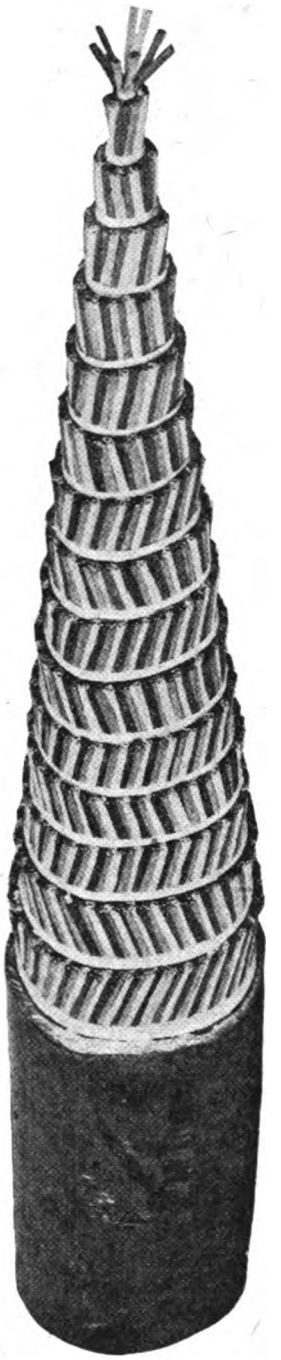
It was nearly a year and a half after Bell had filed his specifications that the first telephone company was formed. The Bell Telephone Association was started in August, 1877, with no capital and four shareholders, Hubbard, Sanders, Bell, and Watson. Bell had offered his invention to the Western Union Company, who refused it, so he formed a rival concern. Bell fought them in the law courts and won. His shares rushed up to 1,000 dollars each. Bell, Watson, and Sanders sold out, and the commercial development of the telephone passed into other hands.

On August 4th, 1922, Bell died in his summer home at Cape Breton, after a life spent in inventing devices to shorten the labours of humanity, and at his burial, as a tribute to the work which crowned his career, all communication was suspended for the space of one minute over the vast network of lines serving the seventeen million telephones in Canada and the United States of America.

Development Begins.

We have noted the work of the most outstanding pioneers in the early days of telephony, but as soon as the telephone entered the commercial arena their name becomes legion.

Needless to say, Thomas Alva Edison, the world's most prolific and versatile inventor, was soon to the fore. In 1878 he produced a carbon transmitter, though he was then in the throes of his epoch-making discoveries in electric lighting, and, when he found that his transmitter would be of no use with the existing receiver, he promptly invented a new receiver. About the same time our old telegraph friend, David Hughes, of England, independently invented the microphone, and unfortunately for patent lawyers, but fortunately for the telephone industry, did not patent it. Hughes is generally accepted as the inventor of the microphone, but, in addition to Edison, there were two Frenchmen



End of a telephone cable, stripped, showing the large number of twisted pairs of wires (one pair for each subscriber) arranged in concentric layers within the outer lead sheath.

whose names we should not omit. Du Moncel seems to have been the first man to recognise that an increase of pressure between two conductors in contact increased the conductivity; and Clerac, of the French telegraphs, had applied this principle in practice, and had actually lent his microphone to Hughes before even the telephone was invented.

Origin of Modern Instrument.

Still the fact remains that the telephone transmitter as used at the present time is a direct descendant of Hughes's instrument. Francis Blake, of England, made the first outstanding advance, with his carbon button transmitter, and it is of interest to note that at the beginning of broadcasting, seven years ago, an old Blake transmitter was used for some test transmissions on account of its reputation for good articulation.

The Reverend Henry Hunnings, a curate in Yorkshire, produced an excellent granular carbon transmitter about the same time as Blake's invention, and it might be noted by amateur workers in television that Hunnings had not the slightest difficulty in obtaining £1,000 for his invention, which was used commercially for some time in London.

Later on, Michael Pupin, of America, at the beginning of this century, invented the loading coil which went so far to improve long-distance telephony over land, and submarine telephony over short distances, and here again we see the hand of the great mathematical physicist, Oliver Heaviside, of England, as loading coils, like the loaded cable, were based on theories which Heaviside had published some years before.

In the next article we shall consider shortly the present state of telephone development throughout the world, but in a more impersonal way, as we should never be finished if we tried to mention the work of the outstanding telephone experts during the last thirty years. There is one name, however, which we should like to mention now, and indeed which could hardly escape mention in an article on the telephone, however short, the name of the man who has been a leader on the technical side of telephone development from the earliest days, and to whose genius is so largely due the possibility of transmitting speech over vast distances, a name well known to us all—John Ambrose Fleming, of England, the distinguished President of our Television Society.

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A Review—and the Result

The following review of the Editor's book on Television appeared in the issue of "Nature," dated March 9th, 1929:—

"*Television.* By Alfred Dinsdale. Second edition. Pp. xx+180+33 plates. (London: Television Press, Ltd., 1928.) 5s. net.

"In a foreword to this little book Dr. J. A. Fleming recommends it to those who desire an all-round view of the art of television as it exists at present, and of the problems and difficulties which still face the inventors in this novel field of adventure. We entirely agree with him. He also points out that in all inventions like the telephone, radio telegraphy, and television there are two stages of development. First of all an idea strikes someone; then various people try to realise it in practice. The next stage is when an inventor like a Bell, a Marconi, or a Baird, makes an invention or discovers a device, sometimes very simple, which opens up a new pathway, and then progress is rapid. When the right clue is obtained success follows, provided financial aid is forthcoming and systematic experiments are undertaken. The history of the past furnishes many similar cases.

The reader, even although his knowledge of physics is limited, will have little difficulty in understanding this book. There is a great demand by the public for anything new, for anything which contributes to the convenience of life, to entertainment, and to the dissemination of instruction and news. The physical importance of the new discoveries and inventions is considerable, and unlike many theories they are built on a sound experimental basis. The great obstacles to radio television to great distances at present are the disturbances caused by fading, Morse signals, atmospherics, and all the other causes which mutilate the broadcasting of speech and music."

In consequence of the above, the following letters were addressed to the Editor of *Nature*, and appeared in the March 23rd issue of that journal:

"PRACTICAL TELEVISION AND ITS PROBLEMS.

"Though I see that it is largely taken from a foreword written by so high an authority as Sir Ambrose Fleming, I should like to put on record my strong dissent from a sentence in the review of A. Dinsdale's book 'Television,' in the supplement to *Nature* for March 9th. The statement that I object to is: 'The great obstacles to radio television to great distances at present are the disturbances caused by fading, Morse signals, atmospherics, and all the other causes which mutilate the broadcasting of speech and music.'

On the contrary, as a matter of fact, if the difficulties occasioned by all these troubles were entirely eliminated, there would remain two fundamental and, so far as present methods are concerned, insuperable difficulties against obtaining really successful practical radio television.

The first, which applies to all television, either by radio or by wire over distances either long or short, is that with present mechanical methods it is only possible to produce transmitting or receiving apparatus with which the pictures can be divided into numbers of units which, for real success, would have to be multiplied at least by hundreds, if not by thousands.

The second difficulty applies only to television by radio and not by wire, but applies obviously to broadcasting, and consists in the fact that where television is made by radio, such broad bands of frequencies must be used in order to get the necessary details to form really successful images that these bands must cause unbearable interference with all other wireless systems in the neighbourhood.

I may add that I have received both a letter, dated March 1st, and a copy of an article in the *Elektrotechnische Zeitschrift* for Nov. 29th last, from Prof. Arthur Korn, of Charlottenburg, the well-known pioneer in the transmission of pictures by telegraph, that fully bears out these views of mine. He says in his letter: 'In reality, I think that all the present trials of television are without great practical value, and only when it will be possible to receive many hundreds of thousands of elements per second practical television will begin'.

A. A. CAMPBELL SWINTON."

"Mr. Campbell Swinton loses few opportunities of attacking mechanical methods of television. We have seen what we and many experts, including Sir Ambrose Fleming, consider excellent pictures transmitted by mechanical television. It is somewhat late in the day to point out difficulties in the way to experts. As Mr. Campbell Swinton has quoted Prof. Korn, we may be allowed to quote the following extract from a letter dated Feb. 19th, by Commandant Brenot, Chief Engineer of Radio Paris, one of General Ferrié's most brilliant pupils: 'What Mr. Baird has done is far ahead of what the most optimistic spirits could have dared thinking only a year ago at the International Wireless Conference held in Washington'.

Six or seven stations in America are already broadcasting television pictures by various methods with a somewhat limited amount of success. Experimental transmissions on the Baird system will shortly be tried in various continental countries. The matter is being considered at present by the Post Office officials in Great Britain and we are quite content to leave the question of broadcasting television in their hands, as we know that they are competent and quite unbiased.

THE REVIEWER."

It is a matter of considerable gratification to us to find that the potentialities and virtues of mechanical systems of television, which we have always supported, are now receiving such widespread and authoritative recognition.

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The Cathode-Ray Tube in Practical Television

By W. G. W. MITCHELL, B.Sc.
(Joint Hon. Secretary of The Television Society)

In our February issue Mr. Mitchell dealt with some of the aspects of this important subject. In the following article he goes further into the question, and points out some of the (at present) insuperable difficulties which lie in the way of the practical application of the cathode ray tube to television.

WE have previously considered (February TELEVISION), in a general way, the question of controlling a beam of cathode rays for the purpose of practical television. Such a beam, composed of mobile electrons of extreme tenuity and weightlessness, would appear, in theory at any rate, superior to any mechanical method of exploring or picture integrating. But the fact remains that although several attempts have been made, notably by Belin, Holweck, and Dauvillier, the last-named for receiving purposes only, very little success has so far attended these efforts.

It is well known that the negatively charged particles, or cathode rays, consist of flying electrons shot out in *straight lines* from the cathode or negative end of a discharge tube. The position of the anode is of little importance, for the rays will always take a straight path. The average velocity of these rays is about 10^9 cm./sec.* depending upon the type of tube and upon the potential applied to the electrodes. We shall do well to bear in mind that cathode rays are not in the nature of ether waves, but are a stream of electrons, although it is quite practicable to change them into Röntgen rays (X rays) by placing a thin plate of quartz, mica, or glass in their path, or into Lenard rays through a thin aluminium plate.

The cathode rays can be deflected from their normal undisturbed path, either electromagnetically or electrostatically. Magnetic deflection with coils produces an effect exactly the tame as would be produced under the same circumstances in a flexible conductor carrying current towards the cathode along the axis of the tube. In electrostatic deflection, using plates, the particles (being negatively charged) are attracted to the positive plate. To get some idea of the stresses which must be set up, it is usually sufficient with modern tubes to cause a change of 1 volt potential or 1 ampere-turn to produce a deflection of approximately 1 millimetre on the viewing screen. This deflection occurs in the same direction as the electric field, and at right angles to the direction of the magnetic field.

Further, it must be mentioned that cathode rays cast shadows and can exert pressure to the extent of turning a small windmill, as explained in any standard text-book on the subject. When concentrated or focussed to a point they cause intense heat, and platinum, tungsten, etc., can be fused in this way.

It is my purpose in this article to consider some of the inherent objections to their use in practical television and to look into some possible remedies. Before doing so, let us summarise the "pros" and "cons" of the case, putting the favourable aspect first. Cathode rays possess little or no inertia. Under suitable magnetic or electrostatic control a beam of electrons could be made to traverse a screen *either in zig-zag fashion or spirally* at speeds far in excess of any travelling light-spot mechanically operated. They can faithfully reproduce frequencies at

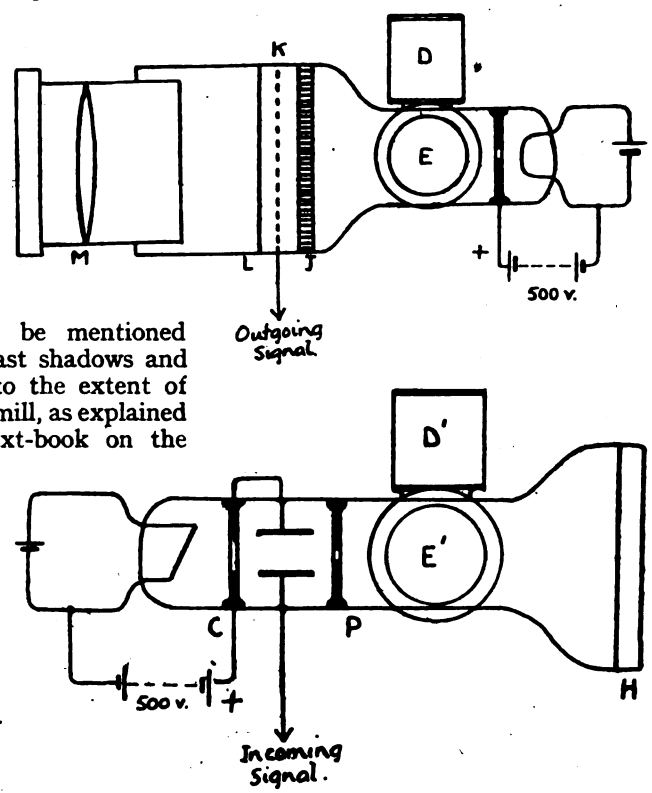

Fig 1.
Mr. A. A. Campbell Swinton's scheme for achieving television by means of cathode ray tubes. Transmitter above; receiver below.

* Becker Ann. der Phys. XVII., page 381, 1905.

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least as high as the upper radio frequencies; their failure in this respect occurs only when the time taken to traverse the screen is comparable with the time taken to cross the tube from the cathode.* A point of considerable importance is the fact that the incoming vision signal,

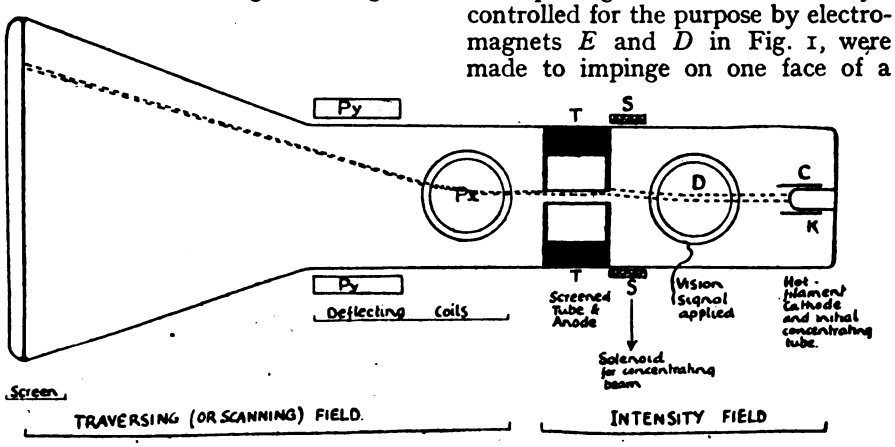

Fig. 2.
Theoretical diagram of improved Receiver.

provided that it is of a certain definite threshold value, can be applied *directly* to the cathode stream without amplification.

Against these reasons we must offset the disadvantages. Unless ample precautions are taken there will be a lack of "sharpness" where the cathode stream impinges on the fluorescent screen. Canal rays move from the anode with a velocity of about 10^8 cm./sec. in the opposite direction to the cathode rays. These canal rays have a strong pulverising or disintegrating power, and by bombardment of the cathode liberate the cathode rays. The life of the tube under these circumstances is comparatively short; 200 hours is a figure given by the manufacturers as the average life of a tube.

Unreliability.

In the present stage of manufacture the tubes themselves are not very reliable; in some cases the oxide coating of the filament tends to separate from the wire, and sometimes, for no apparent reason at all, the tubes fail. And lastly, the high cost and apparent lack of enterprise on the part of most manufacturers are not at the moment conducive to further experimental research along the lines which this article sets out to indicate.

* Kipping.

With these general observations, we will return to the scheme put forward by Campbell-Swinton and already outlined in our previous article. There are two serious objections. In the first place it will be remembered that at the transmitter an exploring beam of cathode rays, controlled for the purpose by electromagnets *E* and *D* in Fig. 1, were made to impinge on one face of a composite screen *J*. This screen consisted of a large number of separately insulated metallic cubes of rubidium, presenting on the one side a clean metallic surface to the exploring beam and faced on the side remote from the rays by a chamber *K* containing sodium vapour.

The image to be transmitted is projected by a lens *M* through a metallic gauze screen *L* on to the screen *J* through the vapour contained in *K*, which is there for the purpose of assisting conduction. It is difficult to see how, under the influence of light, the *entire* plate of photo-electric (rubidium) cubes can be prevented from discharging together. The difficulty is even intensified when the shifting images of moving objects are presented. So that individual exploring by a travelling or zig-zagging pencil of rays, causing a line discharge across the space to the grid, could never really effectively take place but would be overshadowed by the general mass discharge.

Modulation.

Turning now to the receiver (also Fig. 1) we find that use is made of a variable cathode stream modulated in accordance with the incoming vision signal by being deflected from its normal straight line path and will thus be weakened to a greater or less extent by the curvature of its path as it hits an obstruction or passes obliquely through a narrow tube. It will be noticed from the diagram of the receiver that the cathode, which is evidently of the hot-filament type, is set angularly with respect to the axis of the tube so that the cathode rays impinge obliquely on the lower side of the obstruction *C*. The incoming signal is applied to the plates *O*, modulation being effected by electrostatic means by allowing more or less of the electron beam to pass through the obstruction. This preliminary deflection not only varies the direction but also to a very small extent the velocity of the beam. Sir J. J. Thomson has shown that the velocity of cathode rays is not strictly constant; the velocity varies even in the same discharge.

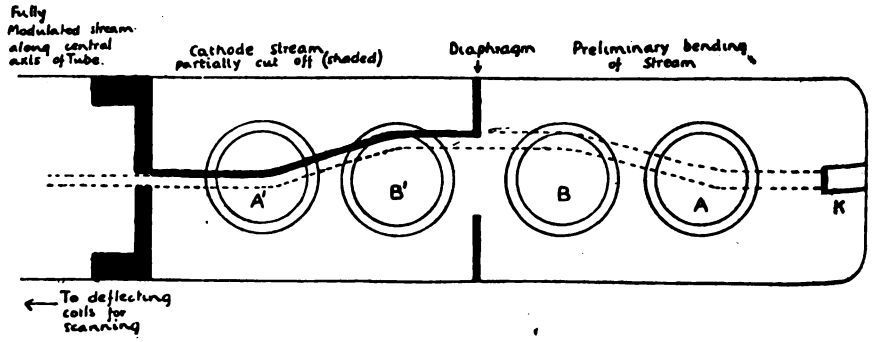

Fig. 3.
Dr. R. S. Clay's proposed method of modulating cathode rays.

The Ideal.

The ideal to be aimed at is obviously to vary the intensity of the cathode ray stream without varying its velocity or direction. A suggestion as to how this may be done will be considered later on in this article, but in the meantime the unsatisfactory nature of an arrangement of this kind will be all

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the more apparent when it is understood that, in addition to being deflected for the purpose of varying the intensity, the same beam has to be rapidly oscillated backwards and forwards across the screen as part of the scanning or image-forming process.

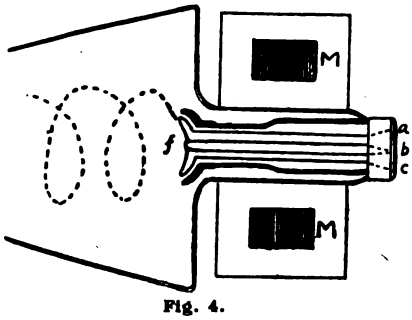


Fig. 4.
Spiral Scanning.

The effect is more clearly shown in Fig. 2, where *Px Py* are two pairs of coils or plates set at right angles to one another either within or without the tube. One set deflects horizontally, say, 20 times per second, the other pair vertically 2,000 times per second. This traversing action alone produces a uniformly illuminated field on the screen by persistence of vision, but before reaching the traversing field the cathode beam has suffered preliminary deflection in the intensity field. Consequently, any initial bending of the stream is superimposed on the deviations produced by the traversing field, causing the beam to move unevenly over the screen and thus injuring the definition.

Dr. Clay's Suggestions.

To lessen the ill-effects produced by the intensity field the electron beam, when passing through the tube *T*, is screened from the influence of this field by enclosing the tube itself in a magnetic shield of iron or permalloy, or when the modulation is effected by creating an electrostatic field with plates instead of a magnetic field with coils, the tube *T* must be made a good conductor of electricity. These suggestions are due to Dr. R. S. Clay, whose final scheme is shown in Fig. 3.

Here we have no less than four pairs of modulating coils. *A* and A^1 are alike and of opposite sense to *B* and B^1, and the diaphragm is inserted between *B* and B^1. But in passing near the coils the electrons are being accelerated, so that to produce equal deflections from each pair and so restore the stream to its original direction Dr. Clay progressively increases the intensities of the coils by increasing the number of turns of wire as the current flows through them in series. Initially, all electrons are cut off and the intensity of the light will rise as the deflection is increased. With this method the maximum swing of the beam may be comparatively large. There is in consequence no reason for keeping the aperture in the diaphragm too small and thus to decrease the threshold intensity of the electron beam as would certainly happen in the case of the arrangement shown in Fig. 2.

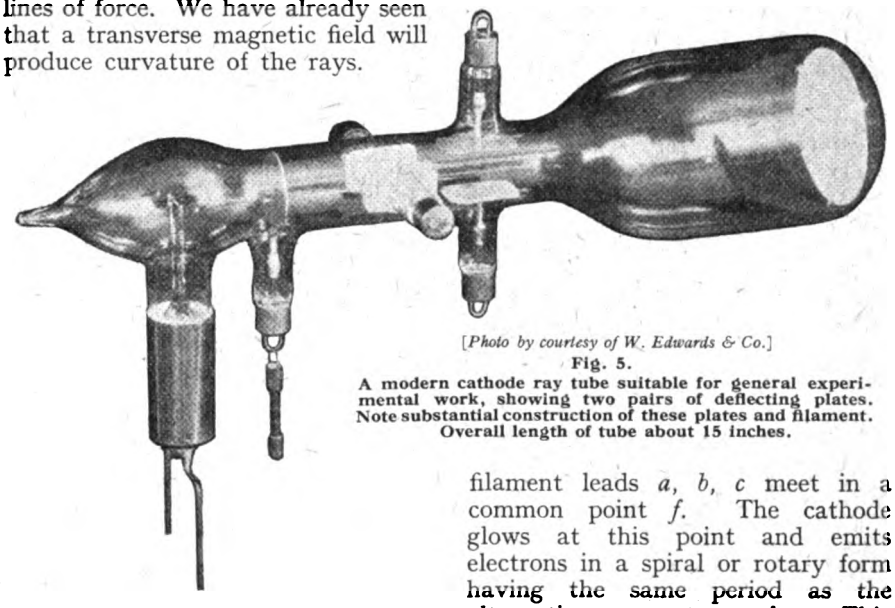
Effect of Magnetism.

Considerable prominence has already been given in the preceding paragraphs to the magnetising effect of a coil on the negative particles forming the cathode stream. Some 40 years ago Hittorf found that when the direction of the rays at their starting-point coincided with the direction of the lines of force the rays continued to travel along the lines of force. We have already seen that a transverse magnetic field will produce curvature of the rays.

If the velocity of the rays is constant and the magnetic field uniform, then the curve into which the stream is bent round the lines of force will be a circle. If the direction of velocity is inclined to the direction of the field, the course of a particle will be compounded of a circular motion round a line of force and an unchanged rectilinear motion along it. Under these conditions the beam will be twisted into a spiral more or less elongated in the direction of the axis of the tube.

In 1921 Schoultz patented a system of spiral scanning in which the cathode beam, instead of being deflected backwards and forwards, was caused to cover a screen by a rotary motion of spiral form. Two synchronous *rotating* electromagnetic fields of varying intensity were employed for this purpose. In this connection it should be remembered that ordinary alternating current dynamos are not designed to produce frequencies of more than about 1,000 cycles per second, and, moreover, there are great inherent difficulties in setting up suitable magnetic fields with such dynamos, apart from the undesirability of introducing moving parts in close proximity to glass tubes.

It has been more recently discovered that rotation of the beam can be effected by using a three-filament cathode heated by three-phase low pressure alternating current. The filament system is shown in Fig. 4, where the separate



[*Photo by courtesy of W. Edwards & Co.*]
Fig. 5.
A modern cathode ray tube suitable for general experimental work, showing two pairs of deflecting plates. Note substantial construction of these plates and filament. Overall length of tube about 15 inches.

filament leads *a*, *b*, *c* meet in a common point *f*. The cathode glows at this point and emits electrons in a spiral or rotary form having the same period as the alternating current supply. This spiral motion can be amplified by the electromagnets *M* fed by current from the same source as the filaments. A metal reflector is fitted behind the filament, which serves both as a screen for the filament and also to project the stream along the axis of the tube. This method is due to Plauson, although no claim is made for its specific use in television.

(*Continued on page* 134.)

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Televising the General Election

As It Might Have Been

A little intelligent Anticipation

By SHAW DESMOND

Author of "Democracy"; "Labour: The Giant with the Feet of Clay"; etc. etc.

WHEN it was known that television was a fact, and that it would be possible for the budding M.P.'s to *show* themselves to the haughty electorate, as well as merely to speak to them, there was a flutter in the Westminster dovecotes.

Mr. Lloyd George at once had a shingle. His friend the enemy, Ramsay MacDonald, had an extra curl put in his moustachios. Winston, the one and only, instantly took a new size and (as some said, thank heavens!) a new shape in hats. Whilst Messrs. Baldwin and Chamberlain rehearsed an entirely new double turn for the television screen.

As for the half-dozen lady members and the half-hundred blushing lady candidates who soon hoped to be M.P.'s, when *they* knew that the television screen was going to be the decisive factor in the 1929 election, they smiled all over. They knew what good looks could do with a male elector.

For both sexes knew that it was not for tariffs or for land schemes that "the tried, trusted, and true" would cast their votes, but for the "good-lookers."

As Mr. Baldwin said ruefully to Austen Chamberlain: "If you didn't have the looks you might as well be off the political map . . . especially with this flapper vote."

"I believe you, Stanley," said Austen in reply. And stuck his monocle a trifle more rakishly in the Chamberlainic eye. There was indeed life in the old dog yet.

The first bombshell flung by the new televising of candidates and their speeches was thrown by, above all others, Mr. Baldwin himself.

He was shown one night just before the poll *without his pipe*, and with a cigarette "on"!

This caused the most dreadful recriminations by the Welsh Wizard, who declared that Stanley had stolen a march on him, and most unfairly. "It's not playing the game, you know, Baldwin," he said. "The flappers love a fellow with a fag. They don't like pipes. And *you knew it*, you bad boy! I was going to do the cigarette trick myself."

The next number was, however, performed by Mr. Lloyd George, and with great effect.

"The little Welsh Wizard," as he was billed, bounced on to the television screen in every home in the land doing his now well-known double conjuring act, during which he showed that black was white and proved beyond cavil that when a politician said what he really meant he ceased to be a politician. Also, he *really* had nothing up his sleeve.

> **"AT some future general election we might, by having land lines to cinemas and halls, show on the screen to thousands of people, say, Mr. Baldwin making a big speech. His words would be heard and his every movement and gesture seen as well."**
>
> [*Extract from a report on television developments, "Evening Standard," April 12th, 1929.*]

At the same time he made a number of promises of what he would do if returned as prime minister—but as all the promises were in Welsh that was all right.

Several excited Welshmen in Tooting and Clapham Common dairies smashed the screen in their excitement.

Labour, feeling that it was up to it to do something now that Wales had stolen the Labour thunder, decided to put on the well-known comedian, Ramsay, "to do his stuff" accompanied by a harp and wings.

If it had not been for a certain unfortunate incursion on the screen this act would have been a complete success.

First, as the intelligent electors gazed upon the television screen attached to their broadcasting apparatus, they saw Ramsay as an Arcadian, clad in an abbreviated angelic garment, a halo around his curling locks, and carrying a broken-stringed harp in his hand, singing his well-known Labour Lament:—

For often to myself I've said:
Cheer up, Ramsay, you'll soon be dead—
A short life and a gay one.

It was towards the end of this cheerful little ditty, given with utter *verve*, that the unfortunate incursion mentioned occurred.

For there rushed on to the screen a thin, sallow, handsome, and dark young man, with a tie of fiery red (for in the new colour television colours are shown). Pushing his chief out of the way, the young man, a dark lock falling across his Robespierre forehead, sang that well-known song: "The One and Only Way!" the chorus of which ran:—

Boys and girls come out to play,
Russia's the one and only way;
Stahlin's the boy we all want to-day,
When we go to the polls in the morning.

It was at this moment that the infuriated Ramsay, lifting the harp, brought it down at a sharp and uncomfortable angle upon the jutting Maxtonian jaw. Unfortunately, ere the now delighted electors could see Mr. Maxton's reply, the televisor was cut off.

It was Winston who brought order

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out of chaos by appearing upon the now relighted screen to tell the world that "Codlin's the boy, not Short." "I do not name any names" the great Westminster knockabout said in his inimitably modest way, "but, although it is not for me to say so, I think you will find that in the long run you'll decide that it doesn't pay to do business with Welshers, nor yet with Scotchmen, but with the old firm, the old firm!"

With that, Mr. Baldwin, who evidently had been waiting in the wings, came diffidently on to the stage dressed as a bookmaker, white topper, checks, spats, and bag all complete, his pipe well on to give confidence.

"The ole firm—the ole firm!" he cried in husky but fatherly accents as he got up on a little stool underneath which his friend Winston stood as a bookie's clerk. "Any odds yer like on anybody yer like. The ole firm—the ole firm! Pay or be paid! Pay or be paid! The old Westminster firm with the old government guarantee! The ole firm! The ole firm!"

It being felt that the Conservatives were stealing all the Liberal thunder, and something desperate being necessary to counter the effect, on the following evening the now thoroughly enlightened electorate were still further illuminated by a stream of beautiful and bouncing chorus ladies rushing on to the television stage when the curtain went up. As it was announced across the curtain: "All under the EXCLUSIVE direction of Mr. Lloyd George, helped by Mr. Charles Cochran."

These delightful young ladies, who, it afterwards appeared, had been specially fattened for the occasion, under the guidance of the famous physician, Dr. Havebutnot Pain, then entranced their invisible audience by singing modern ballads to quaint old settings.

"My Souvenir" sung to "Here we suffer grief and pain," and "Goodbye Blackbird," set to the tune of "I can't come back again, Kathleen," were perhaps the outstanding successes. The solos were: "Homes for Heroes to live in" and "Rare and Refreshing Fruit," the latter set to "The Voice that breathed o'er Eden," both sung by Mr. George, who was in great fettle, caused much emotion amongst the television fans.

"I never heard anything like it in my life," was indeed the comment of Mrs. Bert Budger, of 3a, Laburnum Road, Finsbury Park. The comments of Mr. Budger, an ex-service man, were also interesting and to the point, but need not here be repeated.

The enormous success of the Lloyd George revue aroused, one regrets to say, the basest jealousy in the breasts of a certain small group of his opponents, who promptly announced for the ensuing evening a special act by Colonel Barker, to be entitled "The Softer Sex."

This, however, was a failure, due to its being "jammed" by the clever little Welshman who hired half a dozen special high-powered apparatus for the purpose, showing all his old resource.

Although conjuring acts and bedtime stories, especially the fairy tales in which the leaders of all parties specialised, continued to be the *pièces de resistance* of the political screen, it was due to the almost diabolical cleverness of Mr. Broncho Blurb that a most effective appeal was made to the flapper vote.

Mr. Broncho Blurb, as is well known, was once an agricultural labourer who was brought to see the light (red) in one of the Home Counties through a speech of one of the Auld Lichts of Labour. His ingenuity seems to be endless.

It was he who got the idea from Mrs. Blurb, who got the idea (soon after she had been presented at Court) from Lady Snuffenough, who simply dotes upon Labour members' wives, and to whom Mrs. Blurb had once been "cook and general."

With the intuition of genius Broncho Blurb saw that if you could only knock a guinea off the cost of three-guinea hats "you could get any flapper in England to vote for anybody you damn well please," in Mr. Blurb's homely but convincing language, racy of the soil.

So it was that Mr. Snowden, just before a Labour mannequin parade was thrown on the screen, was put forward to announce that, as a former Chancellor of the Exchequer, and as one who hoped to be one again very shortly, the cause of First Class Hats for Flappers at Second Class Prices had always been dearer to him than anything else in life. "If I am returned," said Mr. Snowden on the screen to the delighted and now screaming flappers, "I shall at once knock off all taxes upon imported straw for hats and forbid any Regent Street or Oxford Street firm to charge more than half a guinea for a two-

Mr. Lloyd George at once had a shingle. His friend the enemy, Ramsay MacDonald, had an extra curl put in his moustachios. Winston, the one and only, instantly took a new size and (as some said, thank heavens!) a new shape in hats. Whilst Messrs. Baldwin and Chamberlain rehearsed an entirely new double turn for the television screen.

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guinea—what did I say?—I mean a three- or even a five-guinea hat."

In vain did the Conservative television headquarters, as that of the Cocoa Party, seek to blanket both the speech and the winning smile of Philip. The deed was done. And as Birkenhead, following the other Napoleon at Waterloo, put it succinctly: "Dammit, the game's up—why didn't *I* think of that!"

After that what was the good of the Countess of Borax and Lady Chillingum having a hundred Bethnal Green babies specially washed for them to kiss, in order to introduce the democratic touch? What was the use of Winston appearing in a last desperate effort to capture the labouring vote; coming on in corduroys and shirt upon the top of a high building to lay his bricks? The mannequins, plus Mr. Snowden, had done the trick. The game, indeed, as Birkenhead had truly said, was "up."

Of course there was a certain set-off to the effect of the mannequin parade by an unhappy *faux pas*, as a Ruskin College man put it, of one of the Labour leaders.

This gentleman had forgotten that not only could his voice be heard, but also that *his face could be seen.*

So it was that, actually in a very bad temper, from a slight domestic difference upon the cost of *tulle*, and not exactly knowing what he was talking about (something shared by many of his political opponents), he made all sorts of wild promises, unfortunately *not* in Welsh, to the listeners-in, who now also were the "lookers-in."

He promised sixpence off the income tax; bonuses for babies; marzipan for nursing mothers; and a sort of Garden of Eden if he were returned. *But he forgot his face.*

Whilst he uttered the beautiful and soothing promises his face was set in an angry scowl (because of that little difference with his wife), whilst in his eyes was the diabolical smile peculiar to politicians who promise something for nothing.

The result was that, seeing the sardonic smile and the scowl alternating, the electors took his promises at their "face," and not at their word, value. And so he lost his voters and his seat.

Truly, the televisor has introduced a new terror into British politics.

It forces politicians to tell the truth.

Dear, dear!

SHAW DESMOND.

[*Copyright.*]

"Any odds yer like on anybody yer like. The ole firm—the ole firm! Pay or be paid! The old Westminster firm with the old government guarantee! The ole firm!"

Cathode Ray Tube.

(*Concluded from page* 131.)

Before cathode rays can be utilised for practical television, a good deal of further research is necessary in arriving at the best method of focussing the cathode beam to a *sharp* point on the fluorescent screen. Allied to this and of equal importance is the question of improving the fluorescent screen itself. In the old type Braun tube concentration of the beam was brought about by emptying a cup-shaped cathode so that the rays are brought to a focus at approximately the centre of curvature of the cathode. With the modern low-voltage hot-filament type of tube a short metal collar is usually placed round the filament, and, further, a solenoid producing a uniform field may be wound round the tube to assist in increasing the intensity and helping the concentration of the beam to a point on the screen, as shown diagrammatically in Fig. 2. The introduction of a small quantity of argon gas into the tube also serves to concentrate the stream to a point.

The coating of the fluorescent screen usually consists of a mixture of calcium tungstate and zinc silicate which, in viewing recurring or transient phenomena, results in a spot sufficiently bright for visual observation and yet containing enough blue light to be fairly active photographically. Brunn has advocated the use of a plate or film of phosphorous for improving the definition. This film may be carried on an endless band which travels successively past the fluorescent screen.

Plauson uses a window made of beryllium or an alloy containing a large proportion (95 to 98 per cent.) of beryllium and 2 to 5 per cent. of aluminium to which a small quantity of magnesium has been added. A thin layer of resistant metal about 1/1,000 mm. thick, such as nickel or platinum, may form a coating of this window.

In the foregoing no reference has been made to the most effective way of producing rapid field changes for causing the electron beam to traverse the screen. This, alike with the many other problems involved in effectively controlling cathode rays, calls for much patient experiment and research.

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The Story of Chemistry

Part VIII

Ionisation

By W. F. F. SHEARCROFT, B.Sc., A.I.C.

THOUSANDS of years ago the Greeks came to the decision that all matter consisted of minute, discrete particles, which they called atoms. Their speculations were vague, and it remained for Dalton to give them precision at the beginning of the last century. We have seen how his mathematical conceptions proved the central point, around which chemistry has revolved since his time. We have seen how the atoms combine together to form other particles, called molecules, and now we come to another order of particles, the IONS, formed when certain molecules dissolve in water.

There is a school of chemists who refuse to believe in these ions in solution, and prefer to explain solution and electrolysis in a different way. Whether they are right or wrong does not matter very much from our point of view. The process of ionisation, as it has been expounded, does offer an explanation, a simple explanation and one which has given rise to much that is of importance. It might be said that the starting point from which television has arisen is the ion as we have described it.

Such a striking phenomenon as electrolysis, and one which had such immediate and practical results, naturally attracted considerable attention. The great experimenter Faraday thoroughly examined electrolysis, and was able to state its laws, which are now known as Faraday's Laws.

Let us return to the electrolytic cell. There, between the electrodes, we detect what we call the *flow* of a current by any of the familiar means of detecting currents that we may choose to select. There is no difference between this current and the current flowing round a wire attached to the poles of a battery or the terminals of a dynamo. But to explain the chemical changes which accompany this *flow* of current through an electrolyte, we have had to imagine that all that happens within the electrolyte is the *flow* of tiny charged particles, which we have called ions. There is a stream of negatively charged particles flowing in one direction, and a stream of positively charged particles flowing in the opposite direction.

This is the eighth of our contributor's series of articles on the story of chemistry, written in simple language, with the introduction only of those chemical formulæ as are essential to an understanding of the subject. In his last article he dealt with the subject of electrolysis. In this article we learn something of another order of particles, called ions, which are formed when certain molecules dissolve in water.

This flow of actual particles constitutes the electric current in the electrolyte. Now, as the electrolyte itself is electrically neutral, it is obvious that the sum of the charges on the negative ions must be equal to the sum of the charges on the positive ions. Further, we have seen that, when the ions reach the electrodes, they give up their electric charges, become uncharged matter such as we are used to, and are either deposited on the electrode or evolved as gases.

It may be possible that the atoms forming any particular ions are not capable of existing as themselves, or as any re-arrangement of themselves. Thus, if we dissolve copper sulphate ($CuSO_4$) in water we get a mixture of positively charged copper ions, and negatively charged sulphate ions. On putting the charged electrodes into such a solution the copper ions will travel to the negative electrode, give up their charge, form molecules of copper, and be deposited upon the electrode, which is the usual method of copper-plating any article, it being made the negative electrode in such a cell. Now the sulphate ions consist of the atoms SO_4, bearing a positive charge. They will travel to the positive electrode, give up their charges, and become ordinary uncharged atoms, and, as the group SO_4, can have no separate existence. No such substance having the formula SO_4 is known, or from valency consideration could such a group of atoms have a separate existence.

We may imagine the group as possessing free valency—free "hooks"—which must be attached to something. Therefore this SO_4 group looks round for something to attack. The only alternatives are the electrode and the water in which the solution is made. Supposing that the positive electrode is made of platinum then the SO_4 group will not attack it, but will go for the water, thus—

$$SO_4 + H_2O \rightarrow H_2SO_4 + (O)$$

The oxygen atoms liberated by this reaction will combine together to form oxygen molecules (O_2), millions of which, sticking together, form little bubbles, and we note the evolution of the gas oxygen. If the positive electrode is made of copper,

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then the SO_4 group will attack this, thus—

$$SO_4+Cu\rightarrow CuSO_4$$

The copper sulphate formed will promptly go into solution and ionise, and the ions become subject to the ionic drift as before. These reactions, taking place at the electrodes between the groups of atoms freed from ionic charges, have nothing to do with the electrolysis. They are *secondary reactions* independent of the influence of the electricity, and taking place only *locally* in the solution. The ionic drift takes place throughout the solution. The word electrolysis is usually stretched, however, to include everything which takes place within the cell. It may be as well to state that there are other ways of looking at the local secondary actions, but for our present purpose the above is sufficient.

Measuring Quantities.

Now it follows that we can, by carefully arranged experiments, collect the materials which are deposited or evolved at the electrodes. We can also measure the quantity of electricity which passes through the electrolytic cell, that is, the quantity of electricity carried by the ions. It is not necessary for us to go into the details of Faraday's work or the considerations which followed it. It will suffice to say that from the results obtained from the figures which were arrived at we can conclude that the charge on any ion is always constant. It was found that the charge on a hydrogen ion was the smallest charge, and that charges on all others ions were either equal to that on the hydrogen ion or simple multiples of it. In no single case do we ever find a fractional charge in terms of the unit ionic charge on a hydrogen ion.

This suggests a limit to the possible magnitude of an electrical charge, the limit being reached with the charge on a hydrogen ion. All ionic charges are made up of a whole number of these unit ionic charges, a conclusion which points to an atomic structure for electricity. The evidence derived from these chemical considerations indicates that electricity is discontinuous as far as ions are concerned. Unfortunately, at the time this possibility was not explored. Faraday and his contemporaries were satisfied with the elaborate schemes of lines of force in a surrounding medium, and felt no inclination to look at electrical problems from any other angle.

The ultimate extensions of this work are outside the province of these articles, belonging more to the province of physics than to chemistry, but it was a chemical phenomenon which laid the first length of track towards our present electronic theory of matter, on which rests the practical details of wireless and its latest development—television.

The ionic theory of electrolysis as we have outlined it was developed by Arrhenius. It offers a ready explanation of the regularity which we have observed in the action between salts, acids, and bases in water solutions. These classes of substances are those which form conducting solutions, that is, solutions consisting of charged ions. In a solution containing a mixture of ions, say $A+$ $B+$ $C-$ $D-$, we imagine a continual motion taking place, resulting in the collision of many millions of ions in a very small fraction of a second.

When oppositely charged ions come into contact we see the possibility of their forming a complete and uncharged molecule such as AC, AD, BC, BD. In fact we are probably near the picture if we imagine these molecules being formed at enormous rates. Now these molecules may either be soluble or insoluble. If they are soluble, then immediately they will split up into their ions again, and as far as we are concerned we shall see no visible sign of the innumerable changes taking place within the solution. If, however, any of the four possible molecules is insoluble then, after formation, it will not re-ionise, but will be precipitated as a solid in the bottom of the vessel.

Ions in Solution.

Thus, for example, if a solution of sulphuric acid be added to a solution of barium chloride, then the following ions will exist in solution—hydrogen $(H+)$, (SO_4-), $(Ba++)$, $(Cl-)$. (The positive and negative indices represent the ionic charges, each sign denoting one unit ionic charge. It will be noticed that the number of charges on an ion is equal to the valency of atom or group of atoms of which it is formed.) These four ions give us the possible formation of the molecules of the substances forming the original solutions, that is, sulphuric acid, H_2SO_4, and barium chloride, $BaCl_2$, and also hydrogen chloride, HCl, and barium sulphate, $BaSO_4$. Of these all are soluble except barium sulphate, which is precipitated as a white solid. The chemical action we represent by the equation thus—

$$H_2SO_4+BaCl_2\rightarrow BaSO_4+2HCl$$

It would be nearer the truth, according to this view, to write the equation thus—

$$2H++SO_4--+Ba++2Cl-\rightarrow BaSO_4+2H++2Cl-$$

It is not imagined that when a soluble salt, acid or base is dissolved in water that the whole of the molecules are ionised at once. At any particular instant only a certain proportion of them are actually ionised, and there is a residue of unionised molecules. Actually a state of equilibrium is set up between the ions and the molecules, which for sulphuric acid we might represent thus—

$$H_2SO_4\rightleftharpoons 2H^++SO_4--$$

and imagine a continual change taking place, in what looks like a quiescent solution.

Degree of Ionisation.

The proportion of molecules ionised depends upon the nature of the solute. Most salts are almost entirely ionised. The strong—not concentrated—acids are very highly ionised in solution, a fact which is used to explain their strength. Their solutions contain a high proportion of hydrogen ion, which is the active part of an acid, or rather the characteristic part. Weak acids, like vinegar, are only slightly ionised. Strong bases are likewise highly ionised. Dilution of the solution of an electrolyte increases the proportion of ionised molecules.

It will be seen also that the important chemical action which we have called neutralisation consists of the union of hydrogen ions derived from an acid with hydroxyl ions from a base to form water molecules, which are hardly ionised at all.

$$H^++OH^-\rightarrow H_2O$$

The ionic theory underlies most of the practice of chemical analysis which is designed to determine the qualitative composition of a substance. The substance is got into solution, and then the ions formed are recognised by making them combine with other ions to form insoluble molecules which can be recognised.

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The Television Society

Mr. J. CAMERON RENNIE, B.Sc., A.M.I.E.E., ON "SOME NOTES ON EXPLORING"

THE April meeting of the Television Society, held at the Engineers' Club, Coventry Street, London, on April 9th, marked a new departure in such meetings, for it was divided into an informal and a formal section. The informal section was presided over by Mr. W. G. W. Mitchell (joint hon. secretary), and was devoted to the discussion of a brief paper on Selenium Cells, presented by Mr. H. S. Ryland. In his paper Mr. Ryland dealt with the main characteristics of selenium cells, and the members present then discussed this interesting subject and asked a number of questions, which were answered.

The formal section of the meeting listened to a paper read by Mr. J. Cameron Rennie (member of council) on "Some Notes on Exploring."

The Vice-President's Speech.

Lord Angus Kennedy presided over this section of the meeting and, introducing the lecturer, said that as the chairman, Dr. Tierney, was unfortunately laid up with influenza, he had been asked to take the chair. They were fortunate in having Mr. Rennie, for he had travelled up specially from Bristol that day. He was going to lecture on "Methods of Exploring." They would remember that Mr. Poole recently dealt with the building up of the picture. Mr. Rennie was taking the other end of television, which was an equally important process.

The last time they met they had their President, Sir Ambrose Fleming, with them. That was on March 5th, the day of the post office official test of Baird television. Since then every member of the Television Society had received a copy of the P.M.G.'s letter as it was published in the Press on March 28th —an epoch-making date, being the first time that the British Government officially recognised television.

He understood that the joint secretary, Mr. Mitchell, had had some correspondence with the managing director of the Baird Company which would, he thought, interest members.

Lord Angus then called on Mr. Mitchell to read a letter from the Baird Television Company, which was dated April 9th, and signed by Captain O. G. Hutchinson, managing director of the company. It stated:

Baird Company's Intentions.

"At present we have under construction about 4,000 televisor sets. These are due for delivery before the middle of June next, and will, therefore, be ready by the time the Brookman's Park Station has been completed.

"It is our intention to sell these as complete units, but later on further lots may be sold in complete kits for those who wish to assemble them themselves.

"In regard to delivery of these machines, it is our intention to give preferential treatment to members of the Television Society."

This letter was in reply to an inquiry from the secretary of the society, pointing out that now it has been definitely promised that experimental transmissions of television will take place at the new B.B.C. station at Brookman's Park in July, a statement as to how soon television receivers would be available for reception would be greatly appreciated by the society. The members, too, the secretary pointed out, would also be glad to hear whether the receivers would be sold complete or in separate parts for assembly. Such information would be of very great interest to the society, as its members included many keen experimenters.

Mr. Rennie, in the course of his lecture on exploring, referred to the "dot" theory of transmission, and said:—

"This conception of looking at individual points of a picture is a true one, but only in a limited degree. Many people, and quite well known scientific men at that, have accepted this view, and have likened the process of transmitting a picture to the examination of a half-tone block in which an image is produced by correlating the different degrees of lighting of small dots which are close together. If this conception of a picture being transmitted and received as a large number of dots were true, it would be impossible to carry out wireless transmission of images. This has been very clearly discussed by Dr. Robinson in the November and December numbers of the TELEVISION magazine, and there is no need for me to go over the ground again.

Older Methods.

"Let it be clearly understood, however, that it would be possible to transmit a picture in that way, and, in fact, for still pictures such a process had been used, although not commercially, by means of a code which represented different tints, so that the picture could be transmitted in the form of a message, the received image being reconstituted by decoding the message and transforming it back into shades or tints over separate equal areas assembled together in a particular order. That, however, was not what happened in television as they knew it to-day.

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"The process of exploration of an object can be carried out in various ways, and the simplest example is the disc with the spiral set of holes. With this exploring device, the circumferential pitch of the holes determines the height of the picture, and the pitch of the spiral determines the width of the picture. Of course, the height and width are interchangeable if the top of the disc is used as the operative portion instead of the side.

"With this kind of device each hole travels down and exposes a strip or band of the object, and each successive hole exposes a further band which lies beside the first band, and this process continues until the whole area is explored.

Dr. Robinson's Articles.

"Dr. Robinson has made it clear in his writings that the transmission does not consist of a series of isolated dots such as occur in a half-tone block, but that for each band the signal is a continuous but varying one, and on these lines he has argued that the fundamental signal should be considered in terms of a number of bands rather than a hypothetical number of dots.

"He worked out examples to show that on this basis wireless transmission of television is possible without occupying an undue space in the ether. I do not think it was made clear in his articles, however, that this argument was capable of still further development in the same direction.

"I am inclined to say that the number of bands is of very little more importance than the hypothetical number of dots, for fundamentally there is no discontinuity between the end of one band and the beginning of the next.

"In the light-spot system of exploration in which the light sensitive cells are continuously exposed to the illumination of the object, and a small spot of light travels over the object in parallel vertical bands, it seems to me perfectly clear that there is no discontinuity behind one band and the next; so far as the cell is concerned it is receiving light from the whole of the object, and at every instant the light which is operative on the cell is made up of two parts, a constant due to the reflected normal illumination of the whole object, and a variable due to the local reflection from the particular point of the object on which the intense spot of light is directed at any instant.

"It is immaterial, so far as the cell is concerned, from what direction the variable quantity of light happens to come, so that if the extent of the picture is defined by the circumferential pitch of the holes, as soon as one spot of light leaves the bottom margin of the picture another spot enters the top margin.

The Engineers' Club, Coventry Street, W., where meetings of the London Section of the Television Society are held.

"It might easily be arranged that the total area illuminated by the intense spot of light is a constant on the edges of the picture, and if that were so there would be perfect continuity of signal in transferring from one band to the next band, and the signal arising from the exploration of the whole object or scene would be in the nature of one variable signal.

"One must be rather tentative in offering suggestions as to what actually takes place in the exploration of an object or scene, because all the published matter of the last two years shows that wrong conceptions have been prevalent, and, in fact, still are prevalent in some quarters. I feel, however, that the extension of Dr. Robinson's statement of the nature of a television signal is justified by actual practice, for although I do not know of any published results, I think it is safe to say that the frequency band occupied by television transmission is considerably less than is called for on Dr. Robinson's theory, and all I am doing is carrying his argument to its logical conclusion to fit in with actual fact.

"In some television systems the synchronising of the receiver and transmitter was effected by means of a special signal occurring once in each band, the signal being such as was given by a black frame to the picture, or a special white band. In that system there would probably have been a discontinuity between the different bands, since the synchronising signal was of a different order of magnitude from

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the picture signals; it might be, however, that when the synchronising systems were improved the synchronising signals would be of the same order as the picture signals, so that discontinuity would be avoided.

"As I have said above," emphasised Mr. Rennie, "any ideas which one may form in respect of the phenomena encountered in the exploring must be tentative, and they must, moreover, be subjected to the acid test of experiment."

The Meaning of Exploring.

Preceding the remarks quoted above, Mr. Rennie had introduced the subject of "Methods of Exploring" by saying television, or seeing at a distance, was fundamentally a method of acquiring information or knowledge of something, and in all the practical proposals for television some system of exploring was used. Everyone knew what was meant by exploration; the dictionary meaning was "to travel or range over for the purpose of ascertaining the nature or extent of something," and that was exactly what was done in television.

While speaking of dictionaries, he pointed out a divergence between British and American practice: the Americans spoke of "scanning" where we spoke of "exploring." The dictionary meaning of "scan" was "to examine point by point; to examine closely or minutely," and that, of course, was equally applicable to the process which was carried out in television. He wished, however, to register a protest against the use of the word "scan," for there was no reason why we in this country should adopt American terminology, since television was first developed in this country.

When first offering the subject he had it in mind to deal with some of the problems which arose, particularly in exploring for television purposes, but those questions had already been dealt with in the TELEVISION magazine by Dr. Robinson and others, and he now proposed rather to wander round the subject so as to get some general views on it, for it was always useful to be able, as it were, to sit back and get a view of detail problems in their proper perspective.

At first sight it looked as if exploration in television was something inherently different from our mental and physical processes in acquiring knowledge, but it was not so different. Human beings were blessed with five different senses by which they could make contact with or get information about the world outside. These five ways were feeling, tasting, smelling, hearing and seeing, and they differed from one another in their scope and in their limitations. He had arranged them in that particular order because it was the order of the maximum range at which observations could be made by each one of them.

Feeling implied or necessitated actual and complete physical contact. Tasting was allied to feeling in that a particular kind of physical contact with the object was needed, but, on the other hand, a sample of the object was sufficient. Smelling could take place at a longer range, but again, a particular kind of physical contact was still needed. These three all required a greater or less degree of physical contact, but there was a jump in the series when passing to hearing, for there was no direct physical contact required in that case, but only an indirect contact through some material medium.

Finally, in the case of seeing, there was another jump in the series, for there it seemed that no kind of material contact was required at all.

The range at which the object might be was also governed by the particular mode selected for acquiring information about it. In feeling, they must be close to it; for tasting, they must also be close to it; smelling took place at a longer range; hearing could be at a still longer range; whilst for seeing, the range was unlimited.

The Range of the Senses.

If there was any truth in the suggestion that different modes of obtaining knowledge constituted a progressive series, they might have expected that other characteristics were similarly progressive. Seeing and hearing were both produced by the sensitiveness of an organ to a wave motion, and there was a similarity between them in that the long range at which seeing was possible was effected by high frequency waves, the shorter range at which hearing was possible was effected by lower frequency waves, and if they jumped to the other end of the series, feeling could be defined as zero frequency. Did taste and smell exhibit themselves also by a wave motion at two different frequencies somewhat lower than audible frequency? That seemed to be a question for biologists or physiologists.

He suggested that they take another set of characteristics of the five different waves. Feeling gave in a limited time but little information. Taste and smell, however, each gave the full information of which they were capable, even in a short time. Hearing in a short time gave practically no information, whereas seeing might in some cases give complete information in a short time, or alternatively it might give practically none.

If a prolonged examination by each method was possible, feeling could give fairly full information. Taste and smell could add nothing further to their first instantaneous results; hearing would give full information, and seeing would give full information if it had not already done so in the first instance.

Time Required.

It was probably not correct to say that seeing gave full information instantaneously, because the instances in which it did so were only those in which they were looking for an isolated fact. It appeared, therefore, that for feeling, hearing and seeing they must spend time in order to get the full information, and the time was spent in exploring the field. If one looked at a page of print it was not possible to take in the whole of it instantaneously, but the eye must traverse it line by line in order to become acquainted with it. It was true that the eye could be educated so as to be capable of appreciating gradually larger areas simultaneously; a child when reading started by examining each individual letter, and in time was able to appreciate short words as units without spelling them out. The faculty varied quite considerably with different people, and was largely a matter of experience.

In judging the education of the eye one must not be led away and ignore the very rapid exploring movements of which it was capable.

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If they made some tests on their own eyes to see whether they did actually explore the field of vision or not, he thought they would be surprised to find how much actual exploration the eye did.

When they turned to the problem of television, they found that all the known methods involved exploring the scene or object of which an image was to be transmitted, just as our senses did. The device which took the place of the human eye was a photo-electric cell, selenium cell, or other light-sensitive device, but it was unlike the human eye in that it was not capable of education to the extent that it could appreciate more than one point at a time in its field of vision.

Education of the Human Eye.

The question of the education of the human eye was one that ought to be rather more fully appreciated than it was, because the eye was capable of a very high degree of education, and in fact was educated to a considerable degree in everybody. He was inclined to believe that although the field of vision of the human eye extended over quite a considerable area, the area of really distinct vision, or the information which was conveyed to the brain, was limited to an extremely small amount, and what happened was that a very limited exploration was made in practice.

The education of the eye took place gradually throughout life, and it was very difficult to put oneself in the position of having a completely uneducated eye. For example, when looking at printing in some unknown foreign type, such as Greek, Russian, Japanese or Chinese, one would find one couldn't appreciate the shape of even a single letter without exploring that letter. One might recognise some Russian letters at a glance, but that was only because they bore a strong resemblance to a Roman character with which one was already acquainted.

Another proof lay in the fact that one did not need to see the whole of a letter or character to identify it. The eye recognised some particular feature and assumed from its prior knowledge the presence of the rest of that character.

This characteristic of the eye was well exhibited by the old trick of covering up the lower or upper half of a line of print. If the lower half were covered, it was usually quite easy to read what had been printed by seeing only the upper halves of the characters. The converse was not quite true, because so many of the characters were alike as to their lower halves, but even then it was frequently possible to make a good guess at what was printed by an assumed knowledge of the words which were likely to be present.

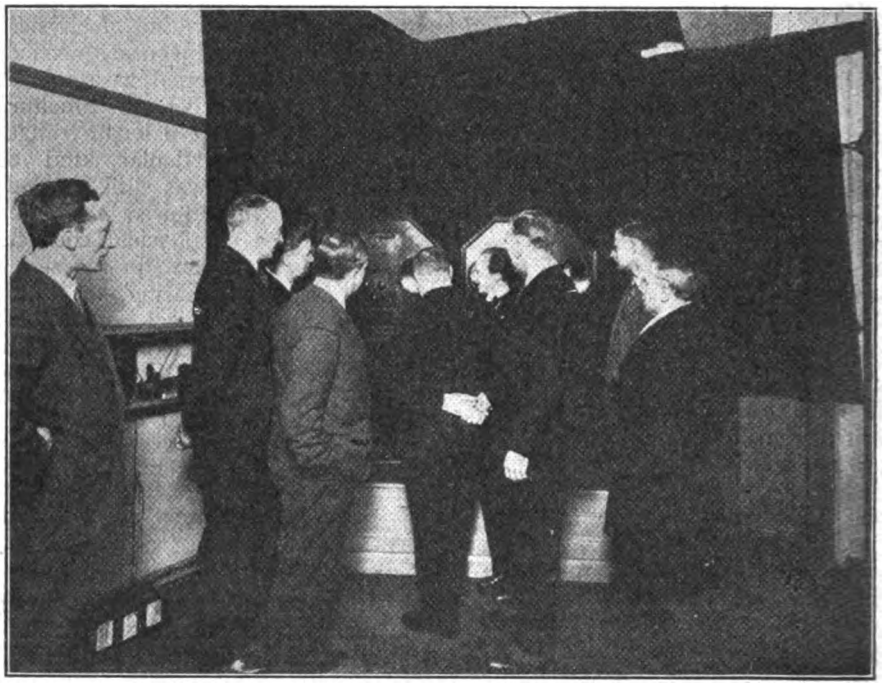
There was an old saying " the eye only saw what it carried with it—the power of seeing." There was no need to give any instances of the truth of that statement.

From all points of view it seemed clear that the electrical eye used in television was not materially inferior to the human eye, except in that one aspect that it was not capable of education.

" The first problem therefore which occurs in a television system is that of providing some device by which the electrical eye can explore the object or view which is to be transmitted," said Mr. Rennie, " that is to say, the eye is to be directed to each point of the object in turn so as to receive an effect proportional to the light emitted from that point, this effect being transformed into the electrical signal which is transmitted to the receiving station."

Mr. Rennie followed up his remarks on the dot theory of transmission, already quoted at the opening of the article, by saying that the process of exploring by a disc with a uniform spiral of holes was one in which the individual bands were traversed all in the same direction, from the top to the bottom of the picture, and the bands appeared successively across the picture from left to right; that was to say, there was a definite continuity in both the vertical and horizontal components of the exploring movement, and he thought it would be found that continuity was extremely important.

The ability to see a complete image derived from some exploring action depended upon what was known as persistence of vision. No one doubted that there was some characteristic of the human eye which gave this effect of persistence. It was admitted also that a fairly definite frequency was necessary to give a continuous effect from an intermittent image; it was usually said that sixteen images per second, as used in kinematography, would give a continuous picture. That meant if the eye was subjected to some light impulse, which might in itself be of quite short duration, the



An interesting group attending a demonstration of Television.

Second from left to right:—Mr. Patterson, Director of Messrs. J. & E. Hall, Ltd., Dartford, together with one of his co-directors; Mr. R. Smith, F.I.C., Chemist, Messrs. Vickers-Armstrong, Ltd., Erith; Mr. Wilson, Director, Messrs. Vickers-Armstrong; Mr. W. Muholland, of Vickers-Armstrong, the Member of the Television Society responsible for the visit of the party; Mr. B. W A. Dickson, General Manager, Vickers-Armstrong; Lord Angus Kennedy and Mr. Denton.

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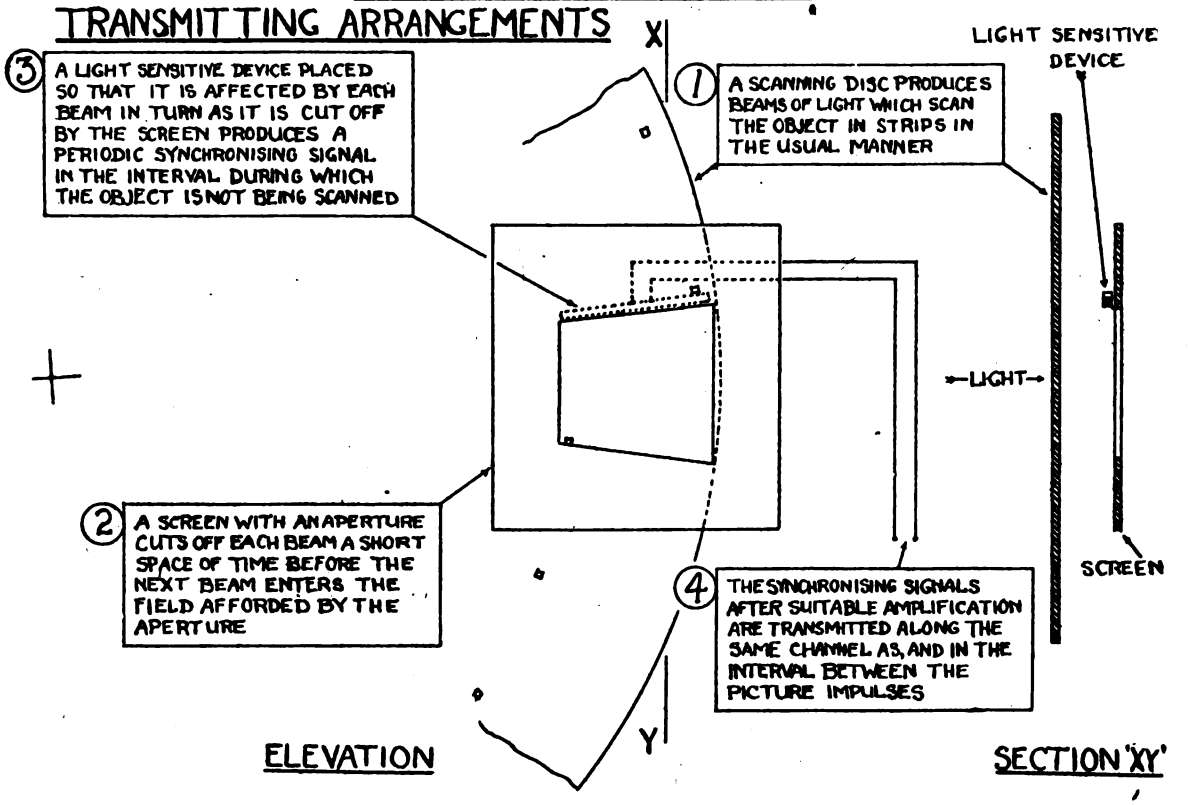
SCHEME FOR AUTOMATIC SYNCHRONISING

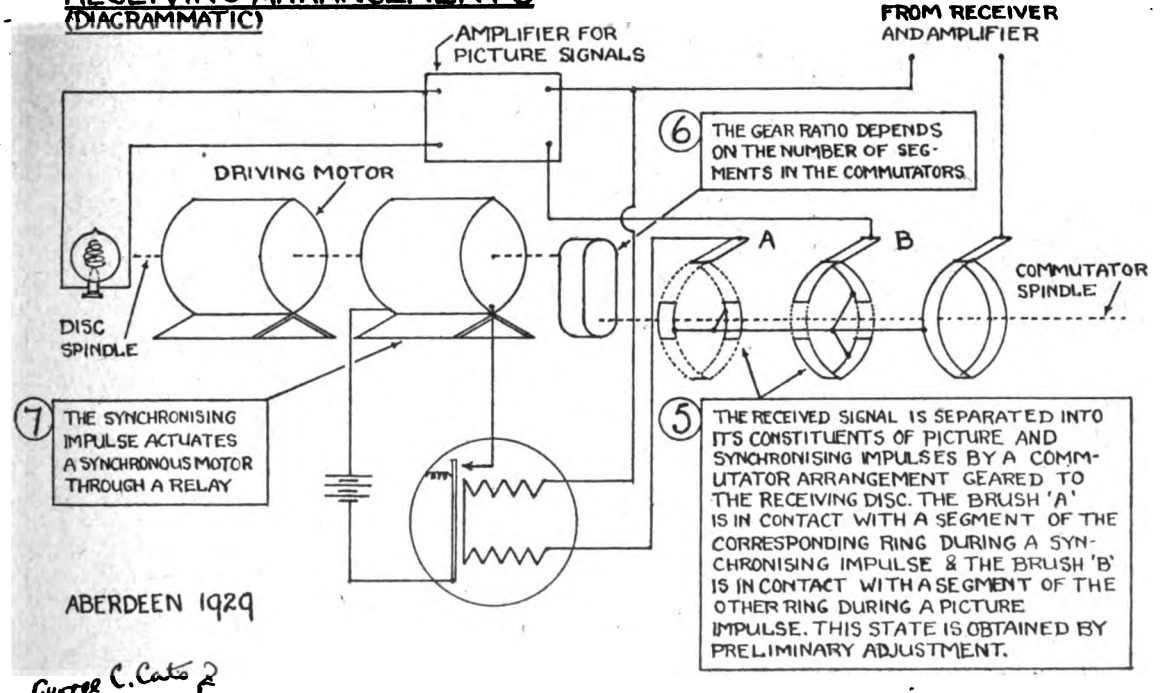
OF SCANNING AND RECEIVING DISCS

TRANSMITTING ARRANGEMENTS



RECEIVING ARRANGEMENTS

(DIAGRAMMATIC)



George C. Cato 2

The above diagram was exhibited at the Society's Exhibition in March, and was unavoidably excluded from the report contained in our last issue, owing to lack of space.

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effects of that impulse would endure for one-sixteenth of a second, more or less.

If a television picture was explored entirely within one-sixteenth of a second, it would not matter how the exploration took place. They might, for example, explore a picture in bands, with an arrangement which displayed first a band on the left of the picture, then a band on the right, then a second band on the left and a second band on the right, and so on. The light impulses would have reached the eye and their effects would have each lasted over a period during which the whole picture was explored. There seemed to be no obvious reason why that would not be equally as good as a method of exploration in which the two components, vertical and horizontal, were continuous. If tried, however, they would find that the effect on the eye was different, and he would be glad to hear some reason for it. The eye, it seemed, liked a continuous movement, as distinct from a discontinuous movement.

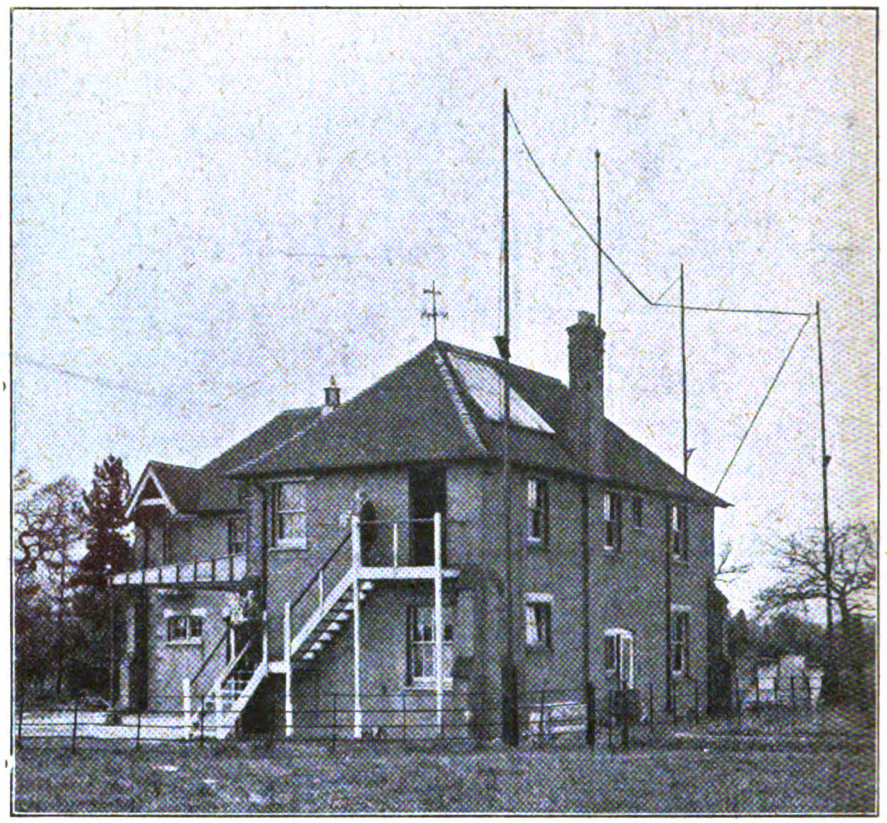
On the question of continuity and discontinuity, there were two interesting facts. If they ran a neon lamp on an alternating current of, say, 50 cycles, they could easily observe multiple images of a moving object which was illuminated by the lamp, and that effect could be obtained with comparatively slow movement.

The other fact was an ordinary kinematograph show. They expected to see pictures without any noticeable flicker.

Peculiarities of Human Vision.

"Is it not peculiar," said Mr. Rennie, "that in the case of the kinematograph, where the object at which we are looking has undoubtedly a discontinuous movement, an appearance of continuity is obtained, whereas in the case of the neon lamp the movement of the object is admittedly continuous, but we get an appearance of discontinuity. A kinematograph picture flickers at the rate of about sixteen per second, while the neon lamp flickers three times as fast, fifty per second.

"If we could run a kinematograph at fifty per second, we should expect it to be, and I think it would be, very much better in its effect of continuity than when running at sixteen per second, but the conditions then would be identical with the neon lamp which gives a discontinuous effect. Education of the eye has something to do with this paradox, the education consisting in the ability of the brain to ignore deficiencies in the information which it receives, but it does not satisfy me as an explanation."



A view of one of the Baird Company's Experimental Laboratories, situated on the outskirts of London.

It had been suggested that exploration might be effected in a spiral direction, or one continuous sweep from the edge to the middle of the picture. If any of them had ever tried that he would like to hear something about it. He had not tried it himself, but he did not think it would be satisfactory for at least two reasons: he doubted whether the continual change in direction would be pleasing to the eye, and he also expected some effects to arise from the big changes in the ratio of linear velocity to angular velocity, or the change which must take place in one if not both.

He had not yet had an opportunity of trying a zigzag exploration, and that might be interesting. That was, of course, the type which was very suitable for use with cathode rays.

There was one other point he wished to mention in connection with exploration. In everything he had read, whether emanating from this country, America or Germany, it had been assumed that the size of the exploring aperture determined the fineness of detail of the image, or the sharpness of the image. It seemed natural that it would, and in any case it obviously had a bearing. There had been quite a lot written about the effect of the size and shape of the exploring aperture, end-effects, and so on, but he ventured to make the suggestion that they had yet a great deal to learn on that particular matter. In practice, and that was what mattered most, he was satisfied from his own observation that if was possible to see detail which was smaller than the aperture and, moreover, to see it clearly. According to ordinary conceptions if the object had two lines on it which were both visible at the same time through an exploring aperture, they should appear as one broad line.

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The fact that they didn't might be due to a trick that his educated eye was playing on him, but equally there might have been some other cause. He didn't know whether anyone had investigated the relationship of rate of change of light with rate of change of cell output at television frequencies.

What is Detail?

While speaking of detail in pictures, there was another aspect of the matter which he had found by accident some time ago. In many natural objects the detail was not so fine as they imagined, and it could be accurately reproduced by quite coarse dots in a half-tone block. One way of observing that was to look at a half-tone block with a considerable degree of magnification, say, 15–25 diameters.

If they focussed the dots sharply, they appeared to be quite definite and discrete dots, and were hardly recognisable as a picture. But then, if thrown gradually out of focus, in many instances they would find that for a certain rather critical degree of blurring, the picture became quite clear in spite of the magnification of the dots. Was that another case of the eye deceiving, or was it a fact? It didn't much matter so long as he saw a picture, but it made him wish he had time to investigate all those peculiar facts and see where they led.

All those matters, however, were, so far as he was concerned, largely speculative, for the more one looked into the question the more one realised that research, and possibly only tedious research, would give an answer, so in conclusion he wanted to be more practical and concrete. He had opened his paper by referring to dictionaries, and he wanted to close it by suggesting that the time was ripe for the society, or the council, to appoint a standing committee which would compile and keep up to date a dictionary or glossary of technical terms used in television.

There was a danger of wrong or misused words becoming standardised by practice in a new art, and in later years that would lead to difficulties and sometimes even hinder development, so if the chairman would allow him he would like to put forward a proposition that a committee of three should be appointed to prepare such a glossary for approval by the council, and further to make proposals whereby the work could be kept up to date as the art and science developed.

* * *

Mr. Ryland, at the conclusion of the lecture, said he would like to say a word or two, first of all, on the question of scanning or exploring. If the picture was made up like a chessboard with a lot of black and white dots then he thought the frequency band occupied would be enormous, because one would get a true dot system of transmission, but the mere fact that the average image transmitted had a very large part of its surface practically equal in illumination, cut down the frequency band occupied enormously. With regard to vision there was only a very small part of the eye which gave correct definition, the rest was trained for movement.

With regard to the very interesting query Mr. Rennie raised concerning a moving object lit by a neon lamp and the kinematograph screen, the object lit by the neon lamp was illuminated fifty times a second, and if it was moving, what one saw was not the object moving but the object illuminated at a number of different places.

The human eye gave continuous vision with intervals as slow as one-eighth of a second, provided it is approximately the same part of the retina which is illuminated each time. That was the explanation of the fact that a moving object lit by a neon lamp was seen not as continuous movement but as a number of distinct objects, the same part of the retina of the eye not being illuminated, but an adjacent portion due to the movement of the object. That, too, probably explained a lot of the detail that one saw in television images despite the actual coarseness of the exploring disc.

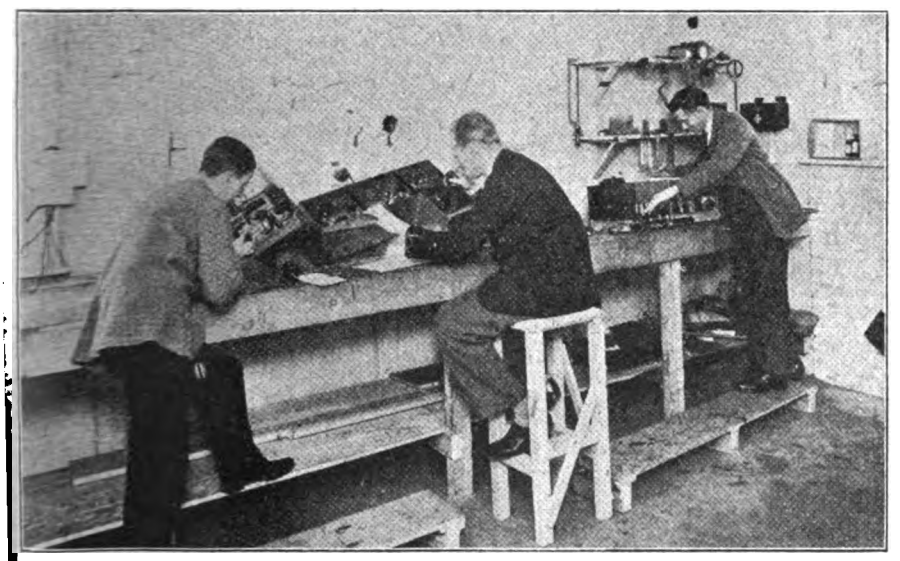
Continuous Scanning.

Another member present wanted to know if there was a definite break between the end of one picture and the commencement of another in television transmissions when they were being scanned by a rotating disc with a given number of holes. Replying to this, Mr. Rennie said that there was no break between one picture and the next.

A very hearty vote of thanks was passed to Mr. Rennie for his interesting lecture. Replying to these, Mr. Rennie said that although he had followed up television very closely he felt that he knew absolutely nothing about it; all he had done in his lecture was to put forward a number of statements all based on experience, particularly where he had made positive statements. He had, however, no explanation to offer for any of them, and all he could say was that with regard to television scanning it was a very vast field for work. The one big conclusion he had come to was that we did not really appreciate the half of what our eyes did for us.

Following the vote of thanks, Mr. Keay said he thought they might

(*Continued on page* 147.)



Research Engineers at work in the Laboratory illustrated on the preceding page.

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HONOURS

By NOËL SWANNE

I GLANCED casually through the honours list, among the S's, but no glow suffused my heart. Of course, a young science like ours cannot expect too much at one time, and so "hats off" to the winner.

* * *

Marjorie put down the April number of TELEVISION.

"It's an awful shame," she remarked.

"Hardly a shame," I said. "Of course, in time recognition must come, but . . ."

"That's just it," she interrupted, "recognition! I don't think you have any right to go on like this."

"My dear girl, I am not going on. Jealousy is not one of my sins. Neither do I envy. Sir Ambrose is . . ."

"What are you talking about?" asked Marjorie.

"As for that, what are you talking about?"

"Electrons," she snapped.

I jerked my mind round, giving myself a nasty crick in the neck.

"Exactly," I continued. "Sir Ambrose is an authority on the subject, as you will have doubtless gathered from that illuminating article, which I hope you have read carefully."

"I say it is a shame," she repeated, and I greeted the remark with silence. "It is just messing about with the things. I wonder if any of you scientists" (I bowed from a sitting position) "ever think about the electron itself."

"We do nothing else," I said, simply.

"Then why not leave it alone, poor little thing."

As usual, I felt lost, and so did some more masterly silence.

"What is an electron?" said Marjorie.

"An electron is . . . well . . . not to be too precise . . ."

"Why not just say you do not know?" broke in Marjorie.

"There are those who hold that the electron is a concrete entity . . ." I began.

"That is more than the stuff is which you promised to put at the bottom of the lily pond," commented Marjorie.

". . . and there is a school which considers that the electron is a wave," I continued.

"There you are—with your entities and your waves! Actually you don't know what an electron is. I expect it will turn out to be a vitamin. It is perfectly shameful the way you go on with the thing. It may have feelings of its own. It may have a wife and a family, and all you do with it is to make it bombard things. I think the Royal Society for the Protection of Something or other ought to know about you."

All that I have ever done with an electron is to . . . well . . .I don't think I have ever done anything with an electron. I'm a peace-loving man and never bombard anything, either. It is all very well for Marjorie to blame me, but just because I happen to contribute to TELEVISION, it does not follow that I am one of those . . . well . . . you know what I mean. Of course . . . yes . . . of course. You see that, don't you?

"Look here, let's get this straight," I said. "This electron business is not my fault. There was a time when the electron was unknown."

"Like yourself," said Marjorie.

"Yes . . . I mean . . . yes. There was . . . WAS. Past tense, passive mood . . . I do wish you wouldn't interrupt like this. I lose the thread of my thoughts."

"What you need is tarred twine to keep your thoughts together," said Marjorie.

"Tarred twine?"

"Yes, the stuff you didn't tie up the rambler with," explained Marjorie.

"Lily pond! Rambler!" I mused. "I'm getting mixed At this time of the year I always write gardening articles. What are we doing now?"

"Electrons!" said Marjorie pointedly.

"Ah yes, of course, the dear old electron. Well, anyway I did not do it."

"Then it is time you did," said Marjorie.

"What?" I asked.

"Took a hand in the game and stopped all this messing about. Just settle the thing quickly in a business kind of way, and let the wave-like entity get on with its job of jumping about, and when you have finished that, there is a trench to be dug for the sweet peas."

* * *

After all, we do not know, do we? There may be something in this dea of stretching out a helping hand to the little electrons. I should be very upset if someone discovered that I was a kind of wave. Supposing they just used me to bombard things. Supposing I was made to jump out of my orbit and lose energy.

I shall found a Society—*The Electron's Aid Society*. The avowed object of this society is to protect the electron from its early youth up to old age. The society will provide vehicles to convey electrons from one orbit to another and so save that devastating jump.

It is a good idea. I shall be known as the man who saved the electron—about the only thing I seem likely to save. Please send your subscriptions at once. There is no limit; and, after all, philanthropy has been known to lead to the honours list.

New Broadcasting Station for Sweden.

The Swedish Government has placed an order with the Marconi Company for the supply of a 60 kilowatt, aerial energy, transmitter for installation at Stockholm.

This contract was obtained by the Marconi Company in the face of the keenest competition. This success is a tribute to the excellent design and performance of British broadcasting transmitters, which have now been installed in over twenty countries outside Great Britain.

The new Swedish broadcasting station will be effective over a very large area. It will be operated on the low-power modulation system, with deep and distortionless modulation; and will be worked direct off a three-phase public electric power supply.

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Focal-Depth in Optical Instruments

The Solar Spectrum as used for the Specification of Optical Glasses

Part X

By Professor CHESHIRE, C.B.E., A.R.C.S., F.I.P.

FOCAL-DEPTH plays an important rôle in the use of the eye and optical instruments generally. Photographs, perhaps, show it in the way best understood, so that the student is advised to carry out the following experiment with a camera :—

Focus as sharply as possible, with the aid of a magnifying glass, the mage of an object, some 15 or 20 feet away, upon the ground-glass screen of the camera, the lens of which is stopped down to about half its maximum aperture.

Now examine the focussed image without the aid of the magnifying glass, and, whilst doing so, get some one to move the object slowly away from, and towards the camera.

It will be found that for quite a considerable range in both directions no perceptible change results in the sharpness of the image on the screen. We will call the nearest point to which the object can be moved without perceptible change of focus the near-point (N.P.); and, similarly, we will call the most distant point which satisfies this condition the far-point (F.P.).

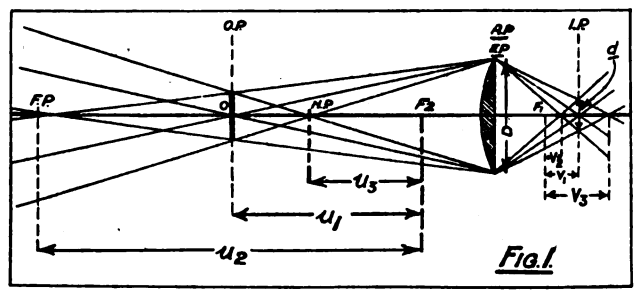
Thus, when an object at *O*, Fig. 1, is in the conjugate plane to that of the focussing screen, all object-points on the axis of the *lens*, between F.P. and N.P., appear to the unaided eye equally in focus with the point *O*.

The distance F.P.–N.P. is known as the focal-depth of the photograph taken under the conditions set out. As every photographer knows, this distance is lessened by increasing the working aperture of the lens, and increased by decreasing it.

Focal-depth depends for its existence upon the fact that the human eye cannot distinguish the focussed image of a point from an out-of-focus image so long as the latter—a so-called "disc of confusion"—does not exceed a certain magnitude. The allowable diameter of this disc, in the case of photographs to be viewed with the naked eye, from the usual distance of 25 to 30 cm., is generally assumed to be of the order of a tenth of a millimetre (1/250 in.).

When a magnifier is employed to view the image, as in the case of the microscope and telescope, a smaller tolerance is necessary. A confusion disc more generally, it may he stated, must not subtend a greater angle than 1/3000 at the eye to be accepted as undistinguishable from the image of a point.

In Fig. 1, let an object-point *O*, in the object-plane (O.P.), at a distance u_1, from the focal point F_2, of the lens, be focussed in the image-plane (I.P.) at a distance v_1, from the second focal point F_1, of the lens. Let the greatest allowable disc of confusion have a diameter *d*. As the object-point moves from *O*, towards the far-point at a distance u_2, the point-image will move towards the lens to a point at a distance v_2, from F_1, such that the cone of rays after passing through their focus will expand and fall upon the ground-glass screen within a circular disc—the disc of confusion—having a diameter *d*. For object-points to the left of F.P. the out-of-focus image, as projected on the screen, will obviously have a greater diameter than the permissible disc of confusion.



Focal-Depth Diagrams for a Photo Lens.

Similarly, cones of rays from the N.P., at a distance u_3, will, after passing through the lens, converge to a point behind the screen, at a distance v_3, and in doing so fall upon the screen in a disc, again with a diameter equal to *d*. For object-points nearer than N.P. the image-disc will have a greater diameter than *d*.

For the given position of the image screen, and the given aperture *D* of the lens, the focal-depth will extend from N.P. to F.P. Cutting down the aperture *D*, clearly, must result in the lessening of the diameter of the confusion disc for object-points at F.P. and N.P.

To obtain the full permissible diameter *d*, with the reduced aperture, the F.P. must be moved further to the left, and the N.P. further to the right, with the result that the focal-depth is increased. Increasing the working aperture, on the other hand, results in a similar way in a lessening of the focal-depth.

An interesting focal-depth problem occurs in connection with the adjustment of the hand-camera of the fixed-focus type for landscape work.

In this case the greatest range of focal-depth is required. Let us suppose then, in the first case, that the lens is adjusted to give the sharpest possible focus for objects at a great distance, or infinity. The ground-glass screen must for this purpose be in the principal focal-plane of the lens.

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If, however, a confusion disc of diameter d is permissible, then an object in the plane O.P. giving such a disc on the screen, in the focal-plane of the lens, will be equally in focus with an object-point at infinity, and objects within the distance u will be more or less out of focus. This distance u gives us the N.P. for the case in which the focussing screen is in the focal-plane of the photo lens. Now $D=f/n$, where n is the f-number, and $p=f^2/u$ so that

$$u=\frac{f^2}{nd} \quad \ldots \quad (1)$$

If, now, we move the focussing screen from the focal-plane back to the plane I.P. it will be seen that an object-point at infinity is still in focus, because its disc of confusion is not greater than d. The point O is now focussed sharply in the I.P. plane so that it can be moved still nearer to the lens to give an image disc of diameter d in that image-plane.

This will occur when the emergent cones of rays from the point O come to a focus at a distance $2p$ from the focus of the lens. Calling u_1, the new N.P. it follows, since $2p=f^2u_1$, that u_1, is half the distance u. By shifting the focussing screen from the focal-plane to I.P. we have then, whilst still retaining the sharp focus of distant objects, halved the distance of the near-point, beyond which all objects are in equally good focus as seen by the eye. Our final equation, therefore, is

$$\text{N.P.}=\frac{f^2}{2nd} \quad \ldots \quad (2)$$

where f is the focal-length of the lens, in inches, n the f-number, and d, the diameter of the greatest allowable disc of confusion, say 1/200 in. The N.P. is thus found in inches.

Example.—Find the N.P. in feet, for a six-inch focus lens working at $f/8$, when the F.P. is at infinity.

$$\text{N.P.}=\frac{6\times 6}{2\times 8\times \frac{1}{200}}=450 \text{ in.}=37{\cdot}5 \text{ ft.}$$
(approx.)

Find the N.P. for the same lens working at $f/32$. Since the N.P. varies inversely as the f-No., other things remaining the same, the N.P. must now be $8/32=\frac{1}{4}$ of 37·5 ft.= 9·4 ft.

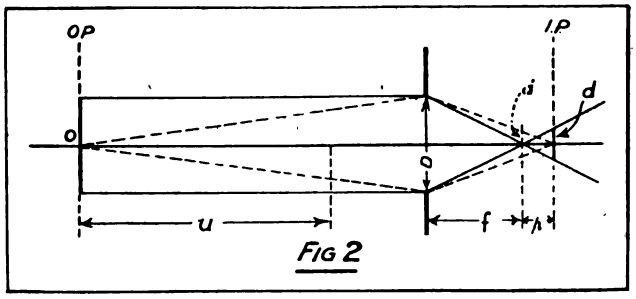

FIG 2

Adjustment of fixed-focus Camera.

Fig. 3 shows a beautiful method of studying focal-depth problems introduced by Professor von Rohr. An image of an object, O, with depth along the axis of the projecting lens, is projected by a lens into the curve I. The focussing screen is at I.P. say, and a plane conjugate to this occurs in the object-space at O.P. All points of the object, such as o_2, which occur in the plane O.P. are imaged as points, such as i_2, in the plane I.P. whilst object-points at greater and lesser distances away than the point o_2 will be focussed in front of the plane I.P. in the former case, and behind it in the latter.

Let us consider the object-point o_1 in the object-spaces. The effective cone of rays taken up from it by the lens and determined by the E.P. intersects the O.P. in a disc of diameter d_1, and the same rays in the image-space intersect the I.P. in the disc s_1 which is, therefore, the image of the disc d_1, since I.P. and O.P. are conjugate planes. Similarly with the object-point o_3. The rays projected backwards intersect the O.P. in a disc of diameter d_3, and this is virtually imaged by the disc s_3 in the plane I.P.

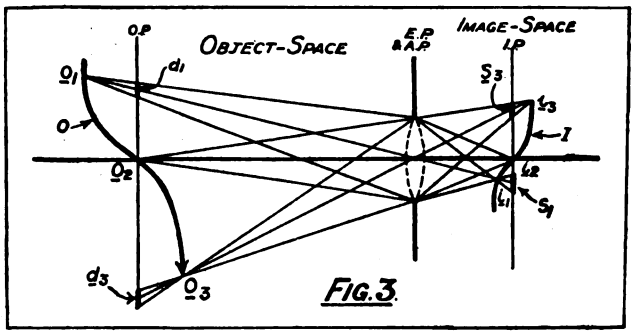

FIG.3.

Professor von Rohr diagram to illustrate Focal-Depth.

In this way object and image points are replaced by discs projected on to the conjugate planes I.P. and O.P., and instead of dealing with object and image points at various distances from the lens, we consider instead their projections from the pupils on to two conjugate and fixed planes—the O.P. and the I.P.*

The Solar Spectrum—Fraunhofer lines—Optical Glass.

The numerical expression of the different refractive powers of glass, and other media, for the different colours, or wave-lengths, of sunlight was made possible by the work of Newton. Propositions I. and II. of his famous treatise on "Opticks," published in the year 1704, summarise his experimental work, carried out some years earlier, on this subject. They read as follows:—

(I.) Lights which differ in colour differ also in degrees of refrangibility.

(II.) The light of the sun consists of rays differently refrangible.

Newton showed that sunlight is made up of a mixture of all the colours of the rainbow, in which he distinguished the seven colours: *red*, *orange*, *yellow*, *green*, *blue*, *indigo*, and *violet*, and that these colours could be separated, and spread out fanwise, by the action of a prism of glass.

Such a prism, he found, deflected the blue rays more than the yellow, and the yellow rays more than the red.

Having made this discovery, Newton went on to find the refractive indices for the various colours in passing from air to glass. He could not, however, do this with any great accuracy, because he could not isolate the spectrum colours suffi-

* Readers interested in this subject are referred to *The Photographic Journal* for January, 1909, p. 3, in which the Traill-Taylor Memorial Lecture, "On the Regulation of the Ray in Photographic Objectives," by Dr. Wandersleb, is published.

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ciently, *i.e.* speaking in modern language, he could not limit his experiments to well-defined and definite wave-lengths of light—he could only obtain bundles made up of rays with refrangibilities varying over an appreciable range.

In the year 1814 Fraunhofer published an account of a remarkable and classical series of experiments which he had made " on the refractive and dispersive power of different species of glass, in reference to the improvement of achromatic telescopes, with an account of the lines or streaks which cross the spectrum.†

The achromatic telescope had been invented by Dollond in 1758, but its performance, in the larger sizes used for astronomical purposes, was severely limited by the fact that the mating of the crown and flint glasses required could not be satisfactorily effected for want of data as to the refractive powers, for the different colours of the sun's spectrum, of the glasses available. Optical bench-marks, to use an analogy, were required for the survey of the spectrum, and these Fraunhofer discovered in " the lines or streaks which cross the spectrum," and which, in honour of their discoverer, are called the Fraunhofer lines of the sun's spectrum.‡

Fig. 4 is a copy of a photograph of the original chart of the solar spectrum, made by Fraunhofer. Throughout the range of the visible spectrum he discovered and mapped some hundreds of these more or less dark lines, now, of course, known to be due to the absorptive effects of the incandescent vapours in the sun's atmosphere, on the light passing through them on its way to the earth.

The more important of the lines were designated by the letters of the alphabet, *A* to *H*, as shown. Since these lines were always associated with the same colour and, therefore, the same wave-length, it was only necessary to make prisms from the glasses under examination and then find the refractive indices for selected lines of the series *A* to *H*, for each, to secure the necessary data for the production of achromatic object-glasses of a much higher order of optical excellence, than had ever before been attained.

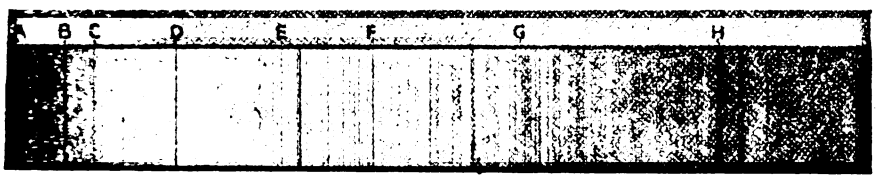

Fig. 4.—The Fraunhofer lines of the Sun's Spectrum.

Professor Cheshire deals with the important subject of focal depth, and in this introduction to the subject of optical glass, and its optical specification, gives us an interesting and authentic reproduction of the famous spectrum chart drawn with the Fraunhofer lines in position by Fraunhofer himself.

The wave-lengths and sources of the chief lines of the solar spectrum are given in the following table :—

Fraunhofer line.	Wave-length in tenth metres.§	Source of light.
A	7661	Oxygen in atmosphere.
B	6867	Do.
C	6563	Hydrogen (α-line).
D	5890	Sodium.
E	5270	Iron.
F	4861	Hydrogen (β-line).
G	4308	Iron.
H	3968	Calcium.

In our next article we propose to take a page from a glass-maker's catalogue and show how the data there tabulated is derived.

† A translation of Fraunhofer's original paper will be found in the Edin. Phil. Journ., Vol. IX., pp. 288–299, 1823 ; and Vol. X., pp. 26–40, 1824.

‡ Newton, so far as is known, never saw the Fraunhofer lines in carrying out his numerous experiments ; and this has occasioned wonder. Apart from any other explanation, however, it is very doubtful whether the prisms used by Newton were good enough, optically, to show these lines. In one significant passage Newton states that certain effects could be seen only " if the glass of the prisms be free from veins, and their sides be accurately planed and well polished without those numberless waves or curls which usually arise from sand holes a little smoothed in polishing with putty."

§ A tenth-metre, or Angström unit, as it is often called, is 10^{-10} of a metre, equal to the one ten-thousandths part of the thousandth of a millimetre. It should be remembered that the wave-length of the *D*-line is ·000589 mm., ·589 μ, 589 $\mu\mu$, or 5890 tenth metres.

Television Society.

(*Concluded from page* 143.)

ask one of the secretaries to give what assurance he could that the suggestion with regard to the compilation of a glossary of terms put forward by Mr. Rennie should be put before the council for consideration. It seemed to him very necessary that such a work should be begun now, in order to prevent the general adoption of any inaccurate or misleading terms in regard to television.

Mr. Mitchell, one of the joint honorary secretaries, said he thought it was a splendid idea, and he would lay it before the council.

A very hearty vote of thanks to Lord Angus Kennedy for presiding concluded the meeting. But, before the members broke up, Mr. Mitchell announced that the next month's meeting would be a practical one. Captain Wilson would talk about his television apparatus, and show them how he had made it and why it worked. It was also hoped that Mr. Garside would bring along his little television receiving machine and demonstrate it. In addition to this, Messrs. Edwards and Company, a London firm, had promised to bring along a cathode ray tube and demonstrate it.

ANNOUNCEMENTS.

The last meeting of the session will take place on Tuesday, May 7th, at the Engineers' Club, and is in the nature of a " practical " evening. An informal discussion will take place at 7 p.m., particulars of which have already been notified to members. At 8 p.m. Captain Wilson and Mr. A. A. Waters will read a paper dealing with the practical aspect of constructing a television transmitter and receiver.

A demonstration will be given by the authors, in conjunction with Mr. Colin P. Garside. Mr. R. R. Poole, B.Sc., is showing a demonstration model explaining the normal process of exploring, and also some unusual methods. A model talking film projector will be shown and explained by Mr. H. S. Ryland.

Any non-members of the Society who would like to be present should apply to the Lecture Secretary for tickets.

J. J. DENTON,
W. G. MITCHELL,
Joint Hon. Secretaries.
95, Belgrave Road, Kensington.

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Three Recent Photo-Electric Devices

By H. WOLFSON

In previous issues Mr. Wolfson has contributed several valuable articles on light-sensitive devices of different types, and on the photo-electric effect. In the following article he describes three photo-electric devices which have recently been developed.

THIS month I am going to discuss three further types of photo-sensitive devices, about which very little information is at present available. The first of these is the so-called "Thalofide" cell, which was discovered by the American worker, T. W. Case.

According to certain accounts of the device which have appeared in scientific publications, the name was given as indicative of the fact that the light-sensitive material of which it is composed contains thallium, oxygen, and sulphur. Some accounts suggest that the active material is thallium sulphide, but they all carefully refrain from pointing out whether thallous or thallic sulphide is meant, while even thallosic sulphides might play a part in the composition of the cell.

Thallous Sulphide.

Its discovery was the result of a long series of investigations with crystalline mineral specimens, and it seems probable that the material used is nothing more than pure thallous sulphide, specially prepared and fused. The liability of thallous sulphide to oxidise in moist air does seem to indicate that the light-sensitive material, starting life as thallous sulphide, Tl_2S, becomes partially oxidised to thallous oxide so that the final composition of the substance would be an indefinite mixture of Tl_2S and Tl_2O. This would reconcile us to the statements referred to above, in which oxygen is mentioned as being present in the active material of the cell.

The preparation of the photo-sensitive "thalofide" material is to be regarded in the nature of a trade secret, as no new facts were brought to light during a recent correspondence between the writer and the Case laboratories.

Thallium sulphide can be most conveniently prepared, however, by fusing together in a small crucible powdered thallium metal, and sulphur. The proportions should be varied and the most satisfactory one determined by experiment, using small quantities for each trial. It will be found that somewhere in the neighbourhood of two parts of thallium to one of sulphur gives quite good results, and it is as well to cover the mixture contained in the crucible with a thin layer of sulphur, in order to prevent undue oxidation when the heating is in progress.

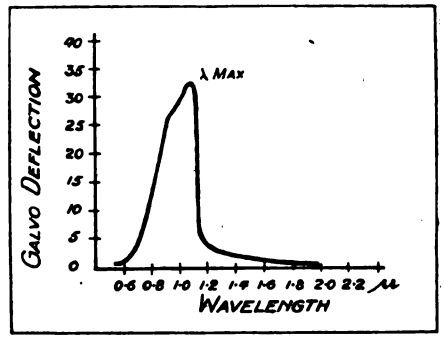

Fig. 1.
Showing colour sensitiveness of the "Thalofide" cell.

Some of the data which is available goes to show that there is a great future for the thalofide cell, and it seems to me that we shall be able, with care, to make these cells as easily as the ordinary selenium cell, and apply it to television transmitters with greater success than is possible with selenium cells. These latter, as is well known, suffer from the time-lag defect, which means that their response to light is not instantaneous. A recent patent (No. 300183), granted to J. L. Baird and the Baird Television Development Co., suggests the use of thallium sulphide in a new form of light-sensitive cell, and this indicates that the thalofide cell is of sufficient importance to warrant a study of its construction and properties.

Two Years' Research Necessary.

Two years' research, according to Case, were necessary before it was possible to produce cells which were very sensitive to light, though apparently ordinary fused thallium sulphide showed a change in resistance on exposure to light.

The photo-active material, after careful preparation, is fused on to a disc of quartz, three-quarters of an inch in diameter. This disc, with two wires attached to act as conductors, is then placed within an evacuated glass bulb, which should preferably be of flashed ruby glass. We shall see the importance of this when we come to consider the colour sensitiveness of the cell.

Effect of a Vacuum.

Enclosing the cell in a vacuum has the effect of increasing the sensitiveness to light about five times, while the life of the cell is also considerably enhanced. Failing the use of ruby glass for the bulb, some suitable colour filter must be used, though this cannot be so satisfactory, as a considerable portion of the light will be absorbed, and much of the intensity lost. This means that current which we obtain from the cell will be much less than with a thin bulb of red glass. Those of my readers who make up the cell may have difficulty in making or obtaining a red bulb, and I would advise that the next best thing is to interpose between the light spot and the cell a sheet of *very thin* flashed ruby glass. This should be bought with care, as much of the red glass of commerce is not suitable.

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Consider now the curve (Fig. 1), which was obtained by plotting galvanometer deflection against the wavelength, in microns (thousandths of a millimètre) of the light to which the cell was exposed.

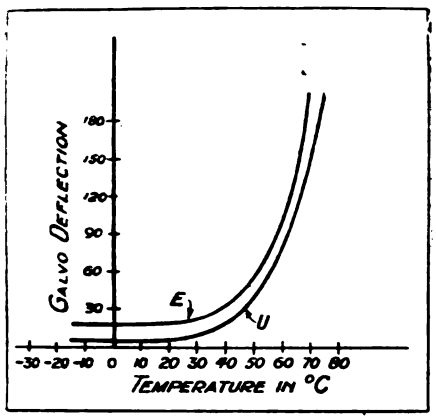

Fig. 2.
Effect of temperature on photo-conductivity of the "Thalofide" cell.
E = Exposed to light during the experiment.
U = Unexposed to light during the experiment.

We see that there is a maximum sensitiveness in the region 0·8μ—1·0μ, while more accurate measurements, carried out at the Bureau of Standards in Washington by Coblentz, show this region to be very narrow, that is, there is a sharp maximum, which is found to occur at 1·0μ or 10,000 Å. This region is outside the visible spectrum, being situated in the infra-red, and the usefulness of this type of cell in noctovision, i.e. infra-red television, will be readily appreciated.

Obtaining a Panchromatic Combination.

This extreme sensitiveness is counteracted by the fact that the sensitiveness in the blue and violet regions of the spectrum is negligible, so that the cell is useless unless the light which falls upon it has a red and infra-red component. In conjunction with a photo-electric cell of the alkali metal type, in which the maximum colour sensitiveness is at the blue end of the spectrum, we would appear to have an ideal combination, which, though by no means panchromatic, is nevertheless a much nearer approximation to this condition.

Harmful Effects.

Blue and violet rays, in addition to their inability to create a response in the thalofide cell, have a definite and marked harmful effect upon it, and it has been found that cells irradiated with blue light for a short period lose their quick response to red light, and continue to do so till they have been kept in the dark for a matter of hours or even days.

The graph in Fig. 2 shows the effect of temperature, which is plotted as abscissæ, while the galvanometer deflection is plotted as ordinates. Two curves are shown. In one case the cell was kept in the dark while its temperature was being raised, and in the other case the cell was exposed to light at the same time as the temperature was being increased, and the readings so obtained are thus representative of the change in conductivity due to the combined effects of light and heat. The conductivity, which is practically nil at zero, rises gradually over the first fifty degrees rise in temperature, and then shoots up suddenly, when the temperature attains about 60° C.

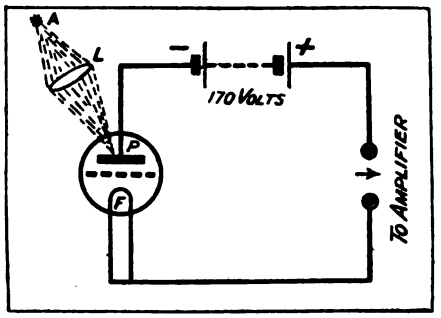

Fig. 3.
Using a valve of oxide coated filament type as a photo-electric cell.
A = Arc lamp. L = Lens system.
P = Plate of valve. F = Filament.

Owing to the special design of the cell, the dark resistance is considerably higher than in the case of selenium, being anywhere from 5 megohms to 500 megohms, but this resistance is lowered, on the average, by 50 per cent. on exposure to light from a tungsten filament, of intensity 0·25 foot candles, though some of the latest and best cells require only 0·06 foot candles to bring about this lowering of resistance.

The cell is worked with a battery in series with it, as in the case of selenium, both these cells being *photo-conductive*, as distinct from the true photo-electric cell. The potential of this battery should never exceed 50 volts, otherwise the cell will be permanently ruined.

Use of Thermionic Valves.

The second type of photo-electric cell, also discovered by T. W. Case, which we are going to discuss briefly, resulted from the investigation of certain high vacuum radio valves, in which the filaments were of the oxide coated variety, the oxides used being those of barium and strontium.

The active material is deposited on the plate of the valve, due to the ordinary changes which take place during the working of the valve in a wireless set. The plate of the valve should be made *negative* to the filament, and the potential required to obtain instantaneous response from this type of cell is the saturation potential, which is about 170 volts. Fig. 3 gives an idea as to the circuit arrangement necessary to use an old valve, which must have been of the oxide coated filament type, as a photo-electric cell. Infra-red rays exercise a deleterious effect, and must be screened out. A current of 7 microamperes can be easily obtained in bright sunlight.

Source of Electrons.

The source of the photo-electrons is found to be a brownish deposit of barium and strontium on the plate of the valve, and this has resulted recently in the manufacture of strontium photo-electric cells, which have been placed on the market. These give on the average a current of 100 microamperes, and they have a maximum colour sensitiveness at 5,000 Å. This is situated in the green-blue region of the spectrum. The barium cells, on the other hand, show maximum sensitiveness between the

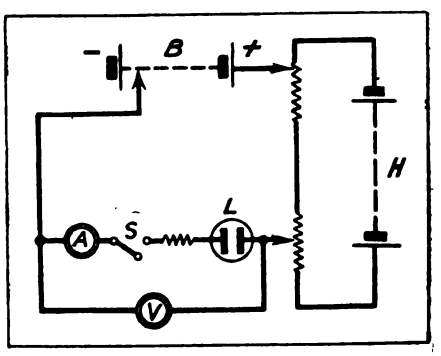

Fig. 4.
Circuit used in investigation of the photo-electric effect in neon lamps.

red and the yellow, while even in the infra-red some effect is produced, though, as already mentioned, these should be cut out by the use of a water cell.

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The third, and by no means least interesting type, which I shall discuss was accidently discovered by Oschwald and Tarrant, while working with a neon lamp. They found that the external illumination exercised a marked influence on the minimum voltage necessary to start the discharge. We have already discussed

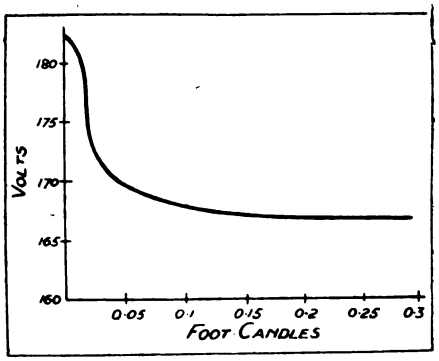

Fig. 5.
Variation of striking voltage of a neon lamp with variation of illumination.

the neon lamp and the various controlling factors in a previous issue of this journal. (See TELEVISION, No. 10, p. 40 *et seq.*)

Ionic Discharge.

The glow of the lamp is analogous to the ionic discharge which we know in the form of the electric arc. In the neon lamp there is a discharge between two metal electrodes. Oschwald and Tarrant found that if the voltage exceeds a certain value (in their case 180 volts, since the figure varies with the particular lamp used) the discharge will commence even though the lamp is shielded from all external ionising agents.

There is likewise a minimum potential of about 140 volts, below which no discharge will take place, nor is it possible to alter this minimum potential by any external agency. By the term "external agency" I mean such ionising radiations as X-rays, radio-activity, etc.

These workers found, however, that a most remarkable external agency will influence the voltage at which the discharge commences, and this is light. As already mentioned above, the normal voltage at which discharge commences is 180 volts. When, however, the lamp is exposed to light, the discharge will start at any voltage exceeding 164 volts.

The method of conducting the tests is really very simple, and since the subject has by no means been thoroughly exhausted, it will be both interesting and important for other workers to take up a similar line of investigation.

Tests for Television Society Members.

Local centres of the Television Society could with advantage repeat and amplify the experiments described in this article, and a few words as to the necessary apparatus will not be out of the way.

Two high-tension batteries having a maximum voltage of about 200 volts are arranged as shown in Fig. 4, the one (*B*) with its ordinary wander-plug as a means of varying the potential, and the other (*H*) shunted by a high-resistance potentiometer having two sliders. This is best achieved by the use of two ordinary potentiometers in series (*P*). An ammeter is placed in series with a switch (*S*), and the lamp and ballast resistance (*L*), all of which are in series with the source of potential difference. A voltmeter (*V*) reading to 200 volts is placed across that portion of the circuit which contains the lamp and ammeter, and should be capable of being read to one or two volts with ease, and should be of a reliable make.

The lamp is first switched on for a few seconds, and then allowed to stand idle for a measured period of time, conveniently two minutes. The voltage is then adjusted to slightly less than that at which it is expected that the discharge will take place, and the current then switched on and raised quickly and steadily till the lamp discharge is started. The lamp switch (*S*) is then opened, and the open circuit voltage is noted.

Results of Tests.

Further readings were taken at two-minute intervals, and it was found that even small intensities of light, such as that produced by a match flame held one metre distant, produced a lowering of the discharge voltage to 164 volts. A graph, which is shown in Fig 5, can be drawn, showing the relationship between intensity of illumination in foot-candles, and the starting potential.

Experiments were also made with a view to determining over what particular range of the spectrum the photo-electric effect was a maximum. The results which they obtained are best summarised in the form of a curve (Fig. 6). The maximum sensitivity is shown by the minimum voltage required to start a discharge, and we see that this is in the orange part of the spectrum.

The next question which arises is the location of that part of the lamp from which the photo-electric effect of the lamp arises. The results obtained show clearly that the seat of the effect must be located on the electrodes, and not in the gas of the lamp. There is no distinction, however, between positive and negative electrodes. Chief among other miscellaneous experiments carried out on this problem by Oschwald and Tarrant, they found that there was no appreciable time-lag with the effect. After long exposure to bright light, if the light was shut off and the current automatically switched on to the lamp at the same time, no discharge took place with a potential of 164 volts across the lamp, which shows that there is no delayed action of light. That is, the effect ceases rapidly and instantaneously when the light which is shining on the lamp is cut off.

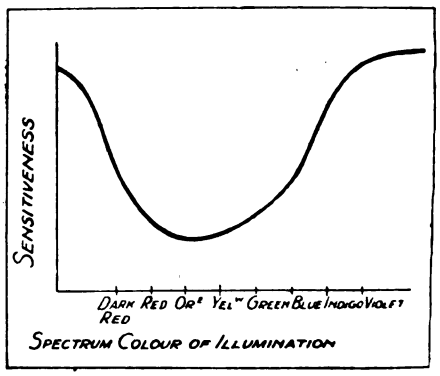

Fig. 6.
Graph giving approximate colour sensitiveness of neon lamp when used as a photo-electric cell.

Type of Lamp Tested.

The type of lamp used was the star electrode Osglim lamp, of the British G.E.C., though the effect is shown to a less marked degree by the beehive type.

Some of the more recently manufactured lamps do not show the effect; indeed it is not desirable that the starting voltage of the lamp should depend on the external illumination, though if there were any demand for lamps showing this characteristic, it would no doubt be met by the manufacturers.

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BROADCASTING AND TELEVISION

The B.B.C. and the Baird Systems

By CLAN CHATTAN

The following very excellent article appeared in the current issue of the " Review of Reviews." The real name of the writer is Major E. R. Macpherson, O.B.E., F.R.G.S., F.A.G.S. He is a Fellow of the Television Society, and has been wireless correspondent to the " Review of Reviews " for over two years. The article is reproduced here by kind permission of the Editor of that journal.

JUST over two years ago I touched on the romantic side of television in these pages. Since then romance has given way to practical development. Television, in the stage of development which it has reached to-day, may be described as a combination of the various branches of science. Mechanics, optics, chemistry, electricity, and even wireless have all contributed to it their quota of knowledge, and have helped in solving the many special problems which are contained in the general problem of true television. By true television I mean ability to see, by some kind of electrical transmission, the reproduction on a screen of the image of moving, living, or stationary objects which are at a great distance from the observer.

Following on the early experiments of Szczepanik, Rosing and Mihály, the problem of television in recent times has been taken up by MM. Belin and Holweck in France; by Mr. C. Francis Jenkins of the U.S.A., and the American Telephone and Telegraph Company. M. Belin, working with M. Holweck, of the Radium Institute, Paris, has succeeded in sending shadows of simple objects. M. Belin's system employs essentially what are known as oscillating mirrors.

Mr. Jenkins uses his novel prismatic disc, an entirely new contribution to optical science, and he has succeeded in broadcasting special shadow films from his laboratory in Washington. The American Telephone and Telegraph Company have achieved a certain amount of success, and their system, whilst very ingenious, is somewhat complicated; they employ the Baird light-spot system. The General Electric Company of America has also explored this system.

However, the credit of being the first man to demonstrate, publicly, true television belongs to John Logie Baird, a brilliant young Scot.

In order to achieve successful television the requirements may be briefly stated as follows:—

*(1) Means of scanning an image, so as to subdivide it into tiny sections, or elements.

(2) Means of transforming the resulting picture elements, or light impulses, into electrical impulses, which can be transmitted to the distant receiver, either by wire or wireless.

John Logie Baird.

(3) Means of reconverting electrical impulses into light impulses, and by means similar to (1), causing them to cover, or illumine, a screen, thus reproducing the image at the transmitter.

(4) Means of synchronising the transmitter and receiver, i.e. causing them to run in step or exactly at the same speed.

These were the requirements as Mr. Baird saw them six years ago.

Many optical methods were already known which would fulfil (1).

The selenium cell and the photo-electric cell were in existence and seemed to cover (2); and for (3) there was the neon tube.

Methods of synchronism had already been developed to a high degree, and seemed to meet the requirements of (4).

It all appeared so simple that Mr. Baird fancied there must be a catch somewhere. He soon discovered that the stumbling block lay in requirement (2)—viz., the light-sensitive cell. A further difficulty lay in (4), for Mr. Baird realised that the usual methods of synchronism were quite unsuitable for television. After six months' work he was able to transmit shadowgraphs, but he found that to transmit the images of the objects themselves was a very different thing.

It was not until October, 1925, that he had the satisfaction of seeing the doll's face (which he used for experiments) on his receiving screen not as an outline, but as a *real* image with shading and detail.

On January 27th, 1926, he gave a demonstration to more than forty members of the Royal Institution, the first demonstration of true television ever witnessed. This demonstration, and others which followed (including the trans-Atlantic tests), aroused considerable interest and enthusiasm. The original machine can now be seen in the South Kensington Science Museum.

Since then Mr. Baird has continually improved the technique of his instruments; and his system (an adaptation of the spot-light and

* " Television." By Alfred Dinsdale. (With acknowledgments.)

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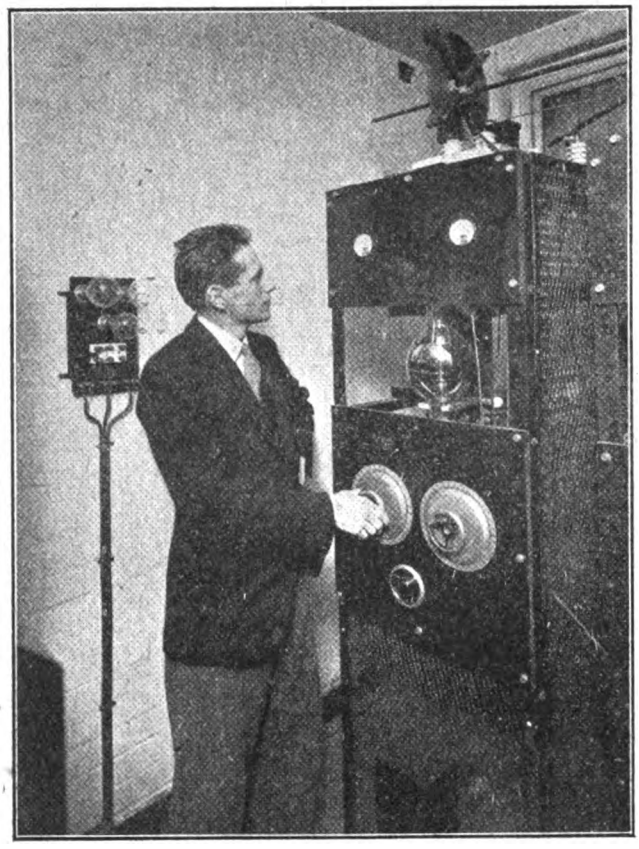


The new Baird Wireless Television Transmitter.

scanning disc) may be briefly described as follows :—

A light proceeding from a brilliant source is condensed into a slender beam not more than an eighth of an inch in diameter.

By means of a revolving disc this spot of light is made to traverse the face of a sitter in such a fashion that it flies across it again and again at slightly differing levels, so as to scan the face completely in less than one-tenth of a second. In front of the sitter's face, but screened from direct light, are a number of photo-electric cells of special design. These cells gather light reflected from that part of the face which at any distance is illuminated by the spot of light.

The photo-electric cells generate a current proportional to the intensity of the reflected ray, and this current is used at the receiver to build up an image by the aid of a neon glow lamp. At the receiving end, slotted and rotating discs then select the light from part of this glow, and deposit it on a screen in such a fashion that each patch of light occurs exactly in the same relative position on the picture screen as it occurred on the part of the object from which it was reflected.

It will be realised that television essentially depends on the fact that an impression made on the retina of the human eye persists for about one-tenth of a second. As this spot of light flies across the screen it builds up an image of the distant object which is seen in its entirety by the persistence of vision.

It is interesting to note that several other well-known experimenters are being converted to Mr. Baird's methods of solving the television problem. Mihály has abandoned oscillating mirrors for discs. Professor Hans Thirring, of Vienna University, is of the same opinion as Mihály.

Our own leading men of science, including Sir Ambrose Fleming, have expressed their high appreciation of the Baird system.

A few days ago I was permitted, through the courtesy of Lord Angus Kennedy, to visit the Baird Laboratories in Long Acre, where every facility was given me to see things for myself.

I was much impressed by what I saw. The improvement in technique since the Radio Exhibition last autumn was most marked. The clarity and detail of vision were such that I easily read the time to a minute on a boldly marked watch held in front of the transmitter (the receiver was, of course, in another part of the building), and I easily recognised the faces of people whom I had seen before.

Music and speech were almost simultaneously transmitted in perfect synchronism ; and in the case of a man playing the piano the limits of the picture permitted the whole keyboard to be seen. I was informed that extended scenes had been successfully transmitted taking in all the performers, though of course the figures were much smaller. They had to be compressed, as it were, into the same area as a head and shoulder view. One can sum up the Baird system in two words : " It works ! "

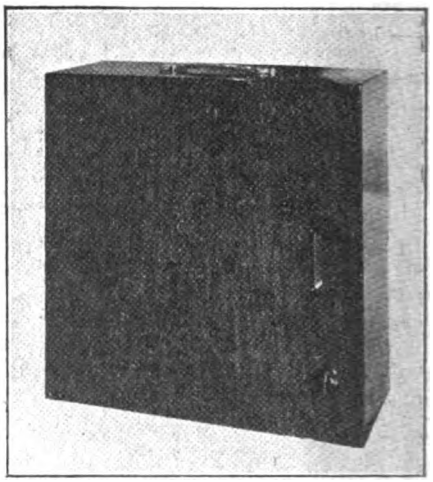
I was also introduced to the wonders of noctovision, where the sitter is in complete darkness, but his face is flooded with infra-red rays (which are invisible to the naked eye), and the image comes out clearly on the receiving screen at the other end. One can imagine the most startling developments from this side-line of Mr. Baird's discoveries. I clearly recognised my friend's face and all the contortions he did for the experiment, despite the fact that he was in complete darkness at the other end.

* * *

During the past few months I have been asked repeatedly : " When is television going to be broadcast ? " Let me explain the situation as I see it.

In *The Review of Reviews* for February, 1927, I wrote : " Television will have to be correlated with broadcasting, otherwise we shall have chaos in the ether." Last October I again wrote : " What the public wants is *living* images. Let us encourage Mr. Baird in his magnificent triumph and press for the broadcast of living people and actual events."

What I have since seen and heard has only served to strengthen those opinions.



Baird Portable Televisor, suitable for use in place of Loud Speaker on any good 4-valve set. Price £12 10s.

After the last Radio Exhibition the Baird Television Company applied to the Postmaster-General for facilities to provide a broadcasting service of television. The Postmaster-General sent a deputation of his

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engineers to examine the apparatus. They reported that, in their opinion, it was sufficiently advanced to warrant tests being made through the B.B.C.

The B.B.C., however, were not of the same opinion, and declined to

Vocalist sitting before Baird Television Transmitter.

allow the tests. A complete deadlock followed for nearly six months.

Pressure (backed up by public opinion) was brought to bear upon the B.B.C., with the result that, quite recently, a series of demonstrations were carried out, and were witnessed by a Committee of Members of Parliament and by the Governors of the B.B.C., with a view to some working arrangement with the Baird Company upon the result of the test.

The strictest secrecy was observed —a policy the harder to understand because the whole subject is of eminent public interest. But I am credibly informed that, during the recent demonstrations, images were successfully received both at the Post Office and at Savoy Hill, and the accompanying speech was heard simultaneously.

Amongst those who were broadcast was Mr. Jack Buchanan, the well-known actor. Captain P. P. Eckersley, the chief engineer of the B.B.C., also took his place in front of the televisor and was recognised at the Post Office.

As a result of these experiments I am delighted to see that the Baird television system has now been officially recognised by the Postmaster-General, who, in a letter addressed to the Secretary of the Company, states that he would agree to a B.B.C. station being used for experimental broadcasts outside broadcasting hours. He refers to Mr. Baird's invention as a "noteworthy scientific achievement." Negotiations are to begin between the B.B.C. and the Baird Company, in order to discuss the technical aspects and other points. This is a happy turn in what was becoming a delicate situation.

I am, and always have been, a great admirer of the B.B.C. Generally speaking, it has ministered to the nation's needs. I felt confident that common sense would triumph, and that Mr. Baird would be given a well-deserved trial. By virtue of its Royal Charter the B.B.C. has a very wide responsibility which it has realised by readiness at all times to consider constructive proposals for its broadcasting service. Also, it has rightly afforded the fullest facilities to the broadcasting of still pictures under the Fultograph* process. The practical value of these pictures to the general public is, however, doubtful. I have been receiving them now for the past two months; and while I admit the cleverness of the instrument, I am disappointed with the technique. But I should imagine that there is a great future for the Fultograph system in the transmission of press photographs over land telephone lines. Some interesting experiments have recently been carried on in this direction.

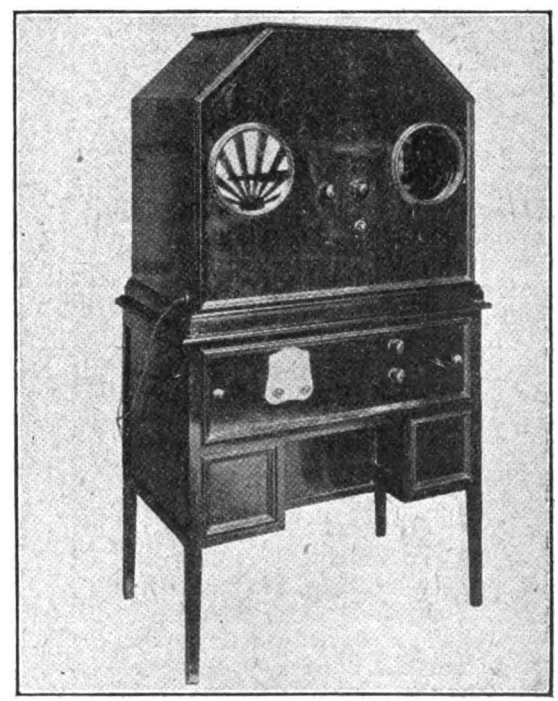
One of the most gratifying aspects of the Postmaster-General's recognition of the Baird system is that a British invention of admittedly outstanding merit is to be developed and explored by British controlled interests. Abroad its value was speedily understood. The Baird Company have been offered every facility by the Rundfunk (the B.B.C. of Germany) and a transmitter has been sent to Berlin. This was done after Drs. Bredow and Reissler had seen demonstrations at the Baird Laboratories. In France no fewer than five stations have been placed at the Company's disposal.

* Wireless Pictures (1928), Ltd.

For domestic use the Baird Company have produced a number of televisor models. The smallest machine (a portable model) shows a picture about twice the size of a cigarette card. In this set 6 volts are required for the motor and 200 to 350 volts H.T. for the neon glow lamp. This instrument only reproduces vision, speech being reproduced on the user's loud speaker. It can be used with any standard four-valve set with a good output valve. The complete Baird televisor reproduces both speech and vision.

In view of the greater H.T. required for television receivers the question of current supply immediately claims our attention, and a suitable eliminator with a large output must be sought.

In the course of my experiments I have been testing large output eliminators. Those supplied by Partridge and Mee of Leicester are excellent in their performance. I have been successfully using their A.C.3 model for some time. This model has a fixed tapping of 400 volts at 50 m.a. and two variable tappings giving 0 to 300 volts. In addition, A.C. filament current for two LS5A valves (in parallel) are provided.



Complete Baird Televisor with Loud Speaker. Price £90

The lay-out of this instrument conforms to the most exacting requirements. There is practically no

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hum, and the manufacturers guarantee their scheduled output, which my tests have confirmed.

With the advent of television I can recommend this firm's eliminators, which are particularly suitable and adaptable for this purpose.

* * *

It has been widely stated in the press that the transmission of television occupies a very wide waveband, so wide that every other station would be obliterated. This is not the case. Recent tests have definitely shown that television can be transmitted within the ten kilohertz band, that is, the frequency band allotted by the Geneva Convention to European broadcasting stations. Mr. Baird readily admits that finality has by no means been reached, and he is confident that further progress will be made in his system if he is given the opportunity to use one or more of the B.B.C. stations. He does not wish to interfere in any way with the ordinary B.B.C. programmes, but suggests that, for one hour every evening, the actors who are broadcasting should also be televised through an additional station—e.g., the Marconi House station, which is, as a general rule, not in use. This would permit the public at large to see practical television for themselves.

The popularity of television is growing rapidly. Little more than a year ago The Television Society* was formed. Its members now number nearly 500, including 200 Fellows. Its President is Sir Ambrose Fleming. The society is international in character, its whole aim being to develop and foster the science of television. I attended the last meeting and was struck by the enthusiasm of its members. Its monthly official organ, TELEVISION,† contains excellent technical articles by acknowledged authorities. The desire to know more grows daily; *listeners-in* now want to be *lookers-in*. I do not doubt that, in twelve or eighteen months' time, we shall have a regular service of *Aurivision* in the British Isles.

* The Television Society, 95, Belgrave Road, Westminster, S.W. 1.

† Published by the Television Press, 26, Charing Cross Road, London, W.C. 2.

Special Broadcasts for Byrd.

An antenna that increases the directional power of W2XAF, the short wave station of WGY, Schenectady, N.Y., ten times, making a 20 kilowatt station the equivalent of 200 kilowatts in effectiveness in one direction, has been erected at the South Schenectady transmitter laboratory of the General Electric Company. This antenna faces the south and it is used for one broadcast programme only, and then but once every other week. The engineers call it the "Byrd" antenna, because when this particular radiator is in use the message is directed to Commander Richard Byrd and his men at Little America, Bay of Whales, Antarctica.

The Byrd antenna is Dr. E. F. W. Alexanderson's contribution to happiness of the expedition personnel as they winter through the long antarctic night. In erecting this special antenna, General Electric engineers are bringing to the Byrd broadcasts the latest devices known to the art to promote reliability of reception. While it is too much to hope that all programmes will reach their Polar destination, it is expected that by the use of the Byrd antenna the chances of getting through static with a good signal are very much enhanced. This particular antenna was used for the first time Saturday night, March 23rd, and within fifteen minutes after the conclusion of the programme, WFA, the Byrd transmitter, reported in code that the entire programme had been received through loud speaker.

An Invitation to Our Readers

In order to stimulate public interest in "Television," and secure new readers, we invite you to send us, on this form, the names and addresses of five of your friends whom you think would be interested to receive a free sample copy.

PLEASE USE BLOCK LETTERS.

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SEND THE COMPLETED FORM TO

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The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. each.

LIGHT MODULATOR.—*Patent No.* 305074, granted to Eccles, W. H., Whitaker, A., and the Gramophone Co., Ltd. The change of illumination in an ordinary Kerr cell is proportional to the square of the applied voltage, but in certain materials there exists a "Pockels' effect" which produces a change of illumination *directly* proportional to the applied voltage. Crystals which exhibit this "Pockels' effect" are used in light valves designed for operation at audio-frequency, so as to yield a photographic sound record. A crystal of Rochelle salt, having the structure shown at (7) in Fig. 1B, is cut along the plane (8), the lower part (14) being discarded. The areas in which the "Pockels' effect" are most marked are indicated at (9), (10). The crystal (1) is shown in Fig. 1A, mounted between two insulating tubes (2) which are closed at their ends by windows (3), and filled with alcohol or some other suitable liquid, and provided with co-axial electrodes (4) and leads (5). The crystal may be arranged between Nicol prisms to yield a photographic sound record. The applied voltage is of telephonic frequency as distinct from modulated high frequency, the use of which is disclaimed, and may be superposed on a direct current polarising voltage in the same or a different direction.

FIG. 1A.

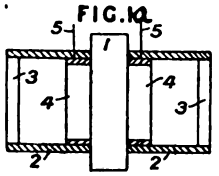


FIG. 1B.

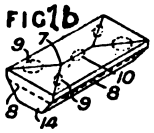


FIG. 3.

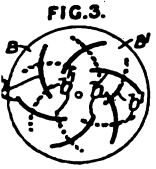


FIG. 2.

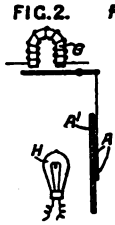
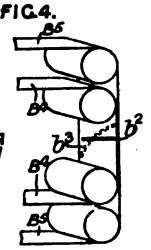


FIG. 4.



SCANNING DISC AND LIGHT VALVE.—*Patent No.* 305079 granted to Rowe, J. J., and Rowe, C. L. The scanning discs *B* and B^1 (Fig. 3) are formed with slots *b* and b^1 (shown with broken lines) respectively. The two discs are made to revolve in opposite directions, one twelve times as fast as the other for scanning purposes, and the slots intersect one another at right angles. Alternately these rotating discs may be replaced by endless bands B^4, B^5 fitted with slots b^2, b^3 respectively, the bands moving in opposite directions at different speeds (Fig. 4).

In Fig. 2 is shown the light valve. The picture to be transmitted is projected through scanning discs of the form already described on to a light-sensitive cell. The output from this cell is amplified and then transmitted either by wire or wireless to operate a magnet *G* at the receiving station. The magnet controls a shutter *A* which works in conjunction with another shutter or slotted screen A^1. Thus the amount of light passing through the dual shutter from a lamp *H*, and thence through scanning discs on to the receiving screen, is controlled in intensity in accordance with the picture being sent.

EXPLORING AND SYNCHRONISING.—Protection is sought in *Patent No.* 304730 by Strange, R. W. (Convention date, Jan. 25th, 1928), for a system of television where a number of objects (10) in Fig. 5 are *simultaneously* explored by a series of spiral perforations in a ring (2). Each object is illuminated from a source (8), and reflected light actuates light-sensitive cells (21). It is claimed that the light may be interrupted by a perforated rotating disc in order to superimpose an alternating current on the output from the cells.

At the receiver the scanning ring (2*b*) has a number of rows of holes shown in Fig. 6 as (3*b*), so that a plurality of images *I*, *II*, *III*, *IV* is reconstructed at each viewing point. A mask (31) can be adjusted so that it may block out the unwanted portions of these images. In this arrangement it is pointed out that it is sufficient for the driving motor at the receiver to run isochronously with the motor at the transmitter.

PICTURE TELEGRAPHY.—The British Thomson-Houston Co. (Assignees of Alexanderson, E. F. W.) claim patent rights in No. 304653 (Convention date, Jan. 23rd, 1928) for a photographic receiving apparatus for picture telegraphy. Picture signals are received on a neon or other lamp (18) in Fig. 7, and the varying illumination is projected through the lens combination (17) on to a photographic film carried by the drum (1). The particular novelty of the invention lies in the method employed for scanning. The drum (1), already referred to, is carried by rods (7) (8) which are mounted on hollow shafts (5) (6), and driven from a motor through a gear wheel (4), so that the drum and shafts rotate within the fixed outer tube. The drum is provided with nuts (11) (12), which

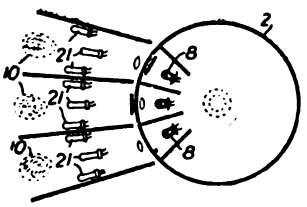


Fig. 5.

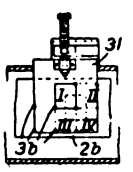
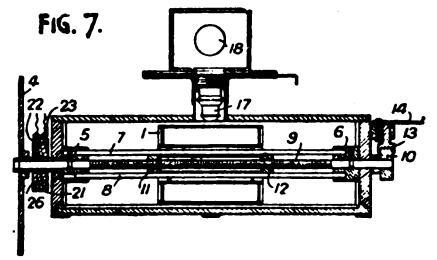


Fig. 6.

engage a screwed shaft (9). The shaft (9) can either run free or it can be held in position by means of the friction brake (10), (13), (14). When the shaft (9) is free it rotates with the drum owing to the friction exerted by the nuts; but when the shaft is held firmly by the friction brake it causes the drum to progress axially while rotating.

A synchronising signal is caused to be emitted once during each revolution at the transmitter. This signal is received in a circuit which includes a telephone and is completed through brushes (23), so long as these lie on conducting portions (21) of the disc (26), which is made to revolve with the drum. When the receiving drum is in phase with the transmitting drum, the signals arrive when an insulated segment (22) is passing under the brushes (23), so that the signals are then extinguished in the telephones. When synchronism has been attained aurally by this means the picture signals are switched through the receiving lamp.

FIG. 7.



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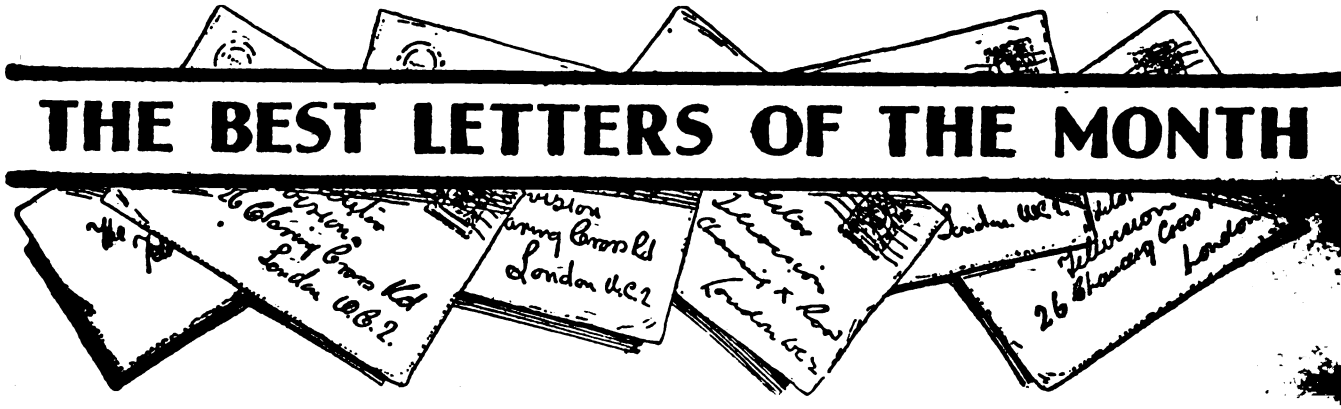

THE BEST LETTERS OF THE MONTH

The Editor does not hold himself responsible for the opinions of his correspondents. Correspondence should be addressed to the Editor, TELEVISION, *26, Charing Cross Road, W.C. 2, and must be accompanied by the writer's name and address.*

UPPER SYDENHAM.

April 4th, 1929.

THE EDITOR,
"TELEVISION."

SIR,

Sir Ambrose Fleming, in an illuminating article in the April number of TELEVISION, says: "We can only conceive of a wave as an undulation in something. What is the 'something' in the case of electrons?"

Substitute spatial ether by a spatial field of static energy. Is this conceivable?

In water or in air eddies may be formed which travel as waves, transferring energy, but neither water nor air. Does a magnetic field of force permit of the passage of undulations such as are carried through and by means of the ether? Apparently it does, as all types of waves move amidst this planet's field of force, yet the lines of force in the magnetic field are one of the elements in the formation of the electric currents which originate some types of waves that are travelling from place to place over this earth.

Magnetism and electricity—as they are exhibited in the physicist's laboratory—are only known as connected with matter. But theory has it that matter is derived initially either as waves or as vortices from the action of electricity upon the ether. We are thus on the horns of a dilemma. We have either to assume electricity as pre-existent to matter, or matter as pre-existent to electricity. In either case the ether does not help us—the ether of current theory, for it is purely a negative substance or condition—subjective, not objective.

Magnetism, lines of force, fields of force, electricity, electro-magnetism are terms freely used in discussing the origin of matter. All we know of magnetism is that certain groups of substances possess qualities resulting in force, while other substances when brought into contact in a certain manner with these will give us motion. For this to be the case the static and kinetic energies existing must be pre-existent to the substances affected. Is it then a far cry to assume a spatial field of static energy capable of becoming kinetic when the conditions are so designed?

Magnetic lines of force are very real and very operative. Planetary fields of force (judging by that of this earth) are real and potent. Following the square law if they exist round about a sun or star or planet, they must fill all space, thus the necessity for a link to avoid "action at a distance" is met. The vehicle is that which is an element in the waves it carries, waves created where right-angle currents are acting, converting static into kinetic energy, travelling as eddies of active force through an ocean of static energy.

I am, Sir,
Yours faithfully,
A. HAYWOOD.

MORE USES FOR TELEVISION.

SHORTRIDGE TERRACE,
NEWCASTLE-ON-TYNE.
April 2nd, 1929.

THE EDITOR,
"TELEVISION."

SIR,

Now that official recognition is coming to television it is to be hoped that the general utility of this great invention will not be lost sight of by those who are inclined to regard it as a specialist thing and treat of it in "Television and Radio" or, as some are doing, "Television in War." There are other and more social uses than these and one that occurs to me is its potentiality along what might be called sentimental lines. We hope in the future to establish television broadcasting stations, when monopolies cease to be, and then it will be possible for persons to see relatives and friends who live at a distance, the person to be seen paying a small fee to pass before the transmitting instrument for his visage and form to be seen in the home televisor hundreds of miles away.

If it is worth a few shillings to telegraph birthday or Christmas greetings to friends at a distance it should be worth a like sum to see them. Those separated from dear ones who have had to seek work or fortune elsewhere will be able by television to see them as in the flesh, after the time had been pre-arranged by letter. Think how cheering it would have bee for all his subjects to have a vision of th King recuperating at Bognor transmitte at intervals, which, I understand, th Baird system could do now if permitted

I am, Sir,
Yours faithfully,
ALFRED S. REEVE.

AUCKLAND,
NEW ZEALAND.

THE EDITOR,
"TELEVISION."

DEAR SIR,

Having acquired an active interest i television through the medium of you very helpful magazine, I should be deeply indebted to you for a little advice an assistance in this growing subject.

Briefly, I have evolved a weird an wonderful system for television tran mission and reception which 'calls for multiplicity of light-sensitive cells of small a dimension (individually) as p sible. Are such cells obtainable? S in cubes of from $\frac{1}{16}$in. to $\frac{1}{4}$in. each. could you advise me as to any kno means for preparing a screen which wo be able to respond to light impulses, individual cells (or other devices) which might be as small as appro mately $\frac{1}{8}$in.? Situated here in N Zealand it is exceedingly difficult to sec much information, etc., and your assistan in the matter would be very much app ciated. Such details as where to procu probable cost, and general cell-efficien will meet my requirements admirably you would be so kind as to officiate for

Needless to add I have gained incentive to put my idea into prac through absorbing the very instruct and interesting articles published in y TELEVISION magazine. I am a regu subscriber and have followed the "n science" very closely as I foresee probable extension of my activities h as radio engineer.

Apologising for encroaching upon y time and trusting that you will be able assist me in the manner indicated,

I am, Sir,
Yours faithfully,
ALLAN PARSONS.

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BAIRD TELEVISION IN GERMANY

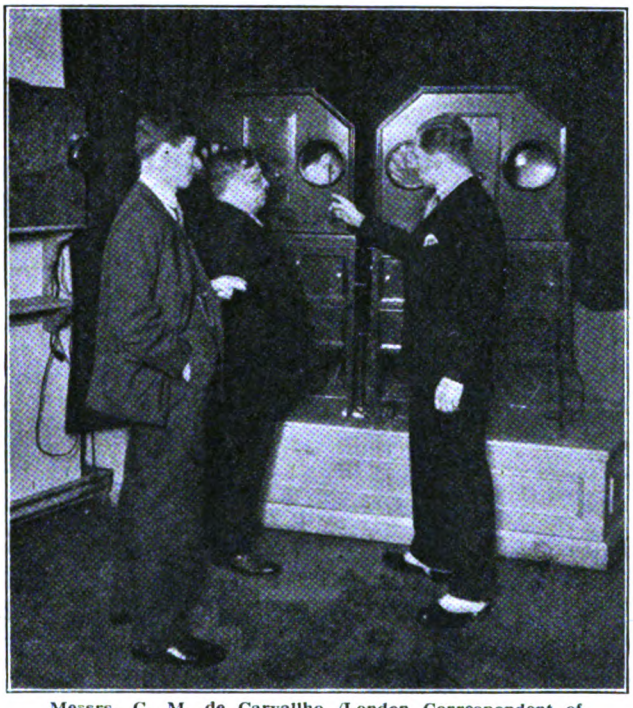
JUN 13 1929

6D MONTHLY

Television

The Official Organ of the Television Society

VOL. 2 JUNE 1929 No. 16



Messrs. C. M. de Carvallho (London Correspondent of "La Scienca," Lisbon), Veiga Adalberto (Secretary to the Portuguese Postmaster-General) and N. B. Reynolds (of Television Press, Ltd.), witnessing a demonstration of television recently. The P.M.G. of Portugal, together with his secretary, are at present in London attending the secret Postal Union Congress.

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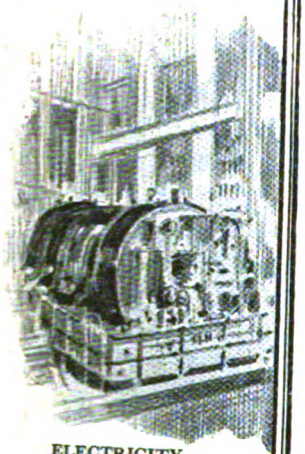

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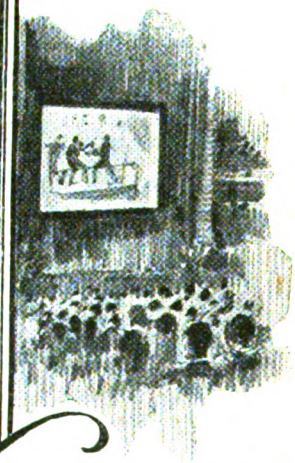

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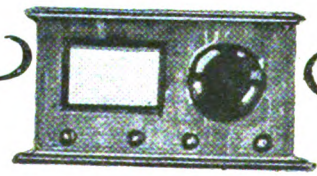

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THE TELEVISION SOCIETY

The Television Society was founded on September 7th, 1927.

The Society makes its appeal to those who desire to share in the responsibility of furthering this new branch of applied science.

THE OBJECTS OF THE SOCIETY

may be summarised as follows :

(*a*) The Study of Television and its application in applied science and industry.

(*b*) To afford a common meeting ground for professional and other workers interested in current research relating to Television and allied subjects and to afford facilities for the publication of reports and matters of interest to Members.

(*c*) To encourage the formation of *Local Centres* of the Society in the Provinces, so that by social intercourse and discussion among members these aims may be more fully realised.

The present register indicates a world-wide membership.

ORGANISATION.

The Society consists of one Honorary Fellow, Fellows and Associates, and the management is vested in a Council of Fellows, including the President, three Vice-Presidents, and Ordinary Fellows.

FELLOWS.—Ordinary Fellows must be elected by the Council. Candidates for the Fellowship must be proposed by two Ordinary Fellows, the first proposer certifying his personal knowledge of the candidate.

ASSOCIATES.—Any person over 21 interested in Television may be eligible for the Associateship without technical qualifications, but must give some evidence of interest in the subject as shall satisfy the Committee.

STUDENT MEMBERS.—The Council have arranged for the entrance of persons under the age of 21 as Student Members.

SUBSCRIPTIONS.—The annual subscription for Ordinary Fellows is 20s., with an entrance fee of 10s. 6d. ; and for Associates 10s., with an entrance fee of 5s.
The annual subscription for Student Members is 5s., entrance fee 2s. 6d.

LIFE MEMBERS.—Life Membership may be secured at a fee of £10 10s.

MEETINGS.—The ordinary meetings of the Society are held in London at the Engineers' Club, Coventry Street, W.1, at 8 p.m., on the first Tuesday of the month (October to May inclusive). Notices of meetings are posted to all members about seven days before the meeting.

Full-size reproduction of the new Television Society Badge, which is available to accredited Members, and may be obtained from the Head Office, price 1s.

The official organ of the Society is "Television," published monthly by the Television Press, Ltd., 26, Charing Cross Road, W.C.2.

A memorandum for the guidance of members wishing to form a Local Centre of the Society may be obtained (gratis) on application to the Joint Hon. Secretaries.

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Television

THE WORLD'S FIRST TELEVISION JOURNAL

The Official Organ of The Television Society

Edited by A. DINSDALE, A.M.I.R.E.

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EDITORIAL

THE article which we published in our last issue, entitled "A Quantitative Analysis of Television," by J. H. Owen Harries, has excited a very considerable amount of interest. A large number of readers have written to us on the subject, and a few of their letters are reproduced on our correspondence page. It is a healthy sign, and most gratifying to us to see with what keen interest our more controversial articles are followed.

* * *

THAT the article in question *is* controversial there can be no doubt. In a completely new science, utterly devoid of all set standards of measurement, every attempt to standardise and get down to a definite quantitative basis is bound to be hotly contested. Mr. Harries is to be congratulated not only on his initiative but also on his courage in making an effort to nail the thing down.

* * *

IT says a great deal for the quality of Mr. Harries' work that no less an authority than Sir Ambrose Fleming has entered the discussion with an article which appears on page 161 of this issue. This article is written in the simple, crystal-clear style which our readers are now accustomed to associate with his articles.

* * *

SIR AMBROSE, while giving due credit to Mr. Harries for his enterprise, not only points out where he thinks the writer is wrong, but also puts forward reasons why, in his opinion, Mr. Harries is somewhat premature in advancing such arguments.

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SIR AMBROSE agrees that some basis or standard of comparison is necessary, so that the relative merits of different systems of television may be adjudged, but he does not agree that we can, at this stage, reduce such a comparison to an exact mathematical basis.

* * *

THE ultimate judge of a television image is the human eye, and the latter has many failings which must be taken into consideration. For the time being, until we have sufficient data available to put the subject on a proper mathematical basis, our eminent contributor suggests a simple form of comparative test which could easily be applied to any television system.

* * *

ON the subject of quantitative measurements, Sir Ambrose Fleming is in a position to speak with some considerable authority. He is already well known to our readers as the inventor of the Fleming Valve, the prototype of the modern wireless valve upon which not only do modern broad-

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cast transmitters depend, but also receivers as well.

* * *

THOSE whose interest in wireless matters is comparatively recent, however, are not generally acquainted with Sir Ambrose (then Dr.) Fleming's connection with Marconi's earliest experiments in this country.

* * *

WHEN those historic experiments were being made from Poldhu, Cornwall, which led, in December, 1901, to the successful transmission of the letter "S" across the Atlantic to Newfoundland, even Marconi himself had no idea what he was doing from a strictly quantitative point of view. He had the inspiration and the conviction that his signals would follow the curvature of the earth, but he did not know of the existence of the Heaviside layer. We know to-day that without this ionised layer in the upper atmosphere wireless signals, instead of crossing the Atlantic, would shoot right off this earth at a tangent, and be lost in outer space.

* * *

MARCONI did not know what current he was radiating from his transmitting aerial until Dr. Fleming suggested the use of a hot wire ammeter as a means of measuring it. He was equally ignorant of the wavelength on which he was transmitting until Dr. Fleming invented the Fleming Cymometer, which enabled him to measure the wavelength. The Fleming Cymometer was the forerunner of the modern wavemeter, one of the most important adjuncts to a wireless transmitter or receiver for obtaining exact quantitative data as to the wavelength (or frequency) to which the instrument is tuned.

* * *

WITHOUT detracting one iota the inspirational and inventive genius of Marconi, it was to Sir Ambrose Fleming that the first wireless quantitative measurements were due.

* * *

Television in Germany.

IN another part of this issue we publish the latest details of the television apparatus developed by Dr. Karolus, in Germany. According to Dr. Gradenwitz, the writer of the article in question, the results obtainable by Karolus are not nearly so good as those obtainable by the Baird system in this country. Dr. Gradenwitz is able to write with some authority on the subject, for he has witnessed demonstrations of the Baird system, not only in London, but, more recently, in Berlin.

* * *

QUITE apart from the capabilities of the Karolus apparatus, the price of the receiver, which is stated to be £400, makes it anything but a commercial proposition. The Baird Company expects to be able to market an efficient television receiver for a matter of £12 only—which is what we had to pay, not so very long ago, for a reasonably efficient loud speaker.

* * *

THE demonstrations of television recently given by the Baird Company in Berlin were, according to reports, highly successful, and they were received with great enthusiasm by officials of the German Post Office and the German Broadcasting Company. In our next issue we hope to be able to record some further interesting developments in this direction.

* * *

When Television Broadcasting Commences.

WHEN television broadcasting commences in this country what will be the effect or result from the average broadcast listener's point of view?

THIS is a question which we have had put to us very frequently of late, and we now propose to answer it.

* * *

TO begin with, of course, the broadcasts will be experimental in character. They are not expected to begin until the new regional broadcasting station at Brookman's Park is ready in July, the reason being that two transmitters are required, one for television and the other for the accompanying music, singing or speech. During the recent Post Office test the Oxford Street and Marconi House transmitters were used, but the latter station cannot be used for regular transmissions because it interferes with the Air Ministry.

* * *

WHEN television broadcasts begin, then the ordinary broadcast listener will still have something interesting to listen to, *i.e.*, the music, singing and speech part of the programme. He will be told, *via* his loud speaker, that if he has a televisor receiver, and tunes to such and such a wavelength he will be able to see as well as hear what is going on in the studio. No doubt many references which he will hear through the medium of his loud speaker will be so tantalising that he will wish he *could* see what is happening. We are convinced that the fascination of fishing for faces on the ether will become irresistible.

* * *

THE important point for the listener who does not possess a televisor receiver, however, is that there will be something intelligible and interesting for him to listen to. And the question arises as to whether the intelligible sound part of these television broadcasts may not prove more palatable and interesting to the average listener than the normal B.B.C. programmes.

* * *

THIS is a useful point which it will be intensely interesting to watch.

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Comparative Tests of Television Apparatus

By Sir AMBROSE FLEMING, D.Sc., F.R.S.

IN the May issue of TELEVISION there is an article by Mr. J. H. Owen Harries, entitled "A Quantitative Analysis of Television," in which a bold attempt is made to include the problem of television within the scope of exact measurement and arithmetic expression.

Mr. Harries deserves a compliment on his effort to bring this new art within the dominion of mathematical analysis. There are, however, some factors in it which I think have been overlooked in his attack on the problem, and to which I should like to direct attention.

It is clear that as progress is made in the practical art some easily applied method will have to be devised for comparing the efficiency or effectiveness or want of perfection in television apparatus. We have to devise means for determining the comparative effectiveness or goodness of various types or makes of television transmitter and receiver.

With this aim in view we must first analyse the phenomena in question. With a good deal of the introductory remarks and analysis of Mr. Owen Harries, I am in agreement, but I think it is necessary first to clear the path by a rather closer scrutiny of what is involved in "seeing" an object or set of objects than he has done.

How We See.

The human eye is often said to be a kind of camera, with its lens, iris diaphragm and screen or retina, and the comparison is correct, though in truth we ought to say the photographic camera is a kind of eye, because eyes were in existence long before cameras.

The peculiarity of the human eye is, however, its extreme mobility. The nearly spherical eyeball is capable of being rapidly moved or rotated in its socket by a set of muscles. The lens forms an inverted optical image on the retina of the external object.

The retina of the eye is a very complex structure, built up of a number of layers of tissue. There is a layer of nerve fibres and ganglions each one of which is the termination of a nerve fibre, and the whole collection of these constitutes the optic nerve, which is in connection with the optic centre in the brain (see Fig. 1).

One small region in the retina, called the *fovea centralis*, is the part of greatest light sensitiveness, and near it is another part called the "blind spot," which is not sensitive at all. In looking at any object we unconsciously turn about the eyeball so as to bring various parts of the image formed by the eye-lens on to the *fovea*. Although the lens of the eye undoubtedly forms on the retina an image of the object looked at, this image is not appreciated as a whole, but by rapid unconscious motions of the eyeball the various parts of the mage are in turn made to fall on the *fovea*.

It is this movement of the eyeball which causes such fatigue in looking at moving objects. When we travel by train and look out at the telegraph posts, palings or trees as they appear to fly past us, we, as it were, fix in succession some object with the eye and follow it a little way in vision, by turning the eye. We then jump the eye to a succeeding object and follow that a little way. The muscular fatigue of these eye gymnastics is considerable and the nervous strain is no doubt, partly at least, the cause of the "train sickness" from which delicate people suffer.

Again, in reading a book or looking at a picture, what happens is that the movements of the eyeballs enable the points of the various black lines which form the letters to be brought in succession on the *fovea* and the shape of the lines to be appreciated, probably by the muscular sensations.

THE article by Mr. J. H. Owen Harries, entitled "A Quantitative Analysis of Television," which we published last month, has aroused a very considerable amount of interest. In this article, Sir Ambrose Fleming discusses Mr. Harries' ideas, points out errors in his thesis, and contributes some valuable suggestions of his own as to how television receivers of different systems might be tested in comparison with a fixed standard.

Requirements for Good Vision.

Leaving out of account differences of colour between adjacent parts of the optic image, what is required for good vision is the ability to appreciate clearly the form of the boundary lines of different parts, say the black and white parts forming, respectively, the images of black lines on white paper, which make up letters of the alphabet, or the boundary lines of the different parts of the images of a face. If these boundary lines are blurred or shaded off we say that the vision is imperfect.

This happens to persons with either short-sighted or long-sighted (elderly) eyes. When a book or printed paper is held about ten or twelve inches from the eye, the lens of a normal eye would form on the retina a sharp image of an external object, but in the case of short sight or long sight the imperfect focus has to be adjusted by spectacles or eyeglasses.

It is necessary, as Mr. Harries points out, that the lines should subtend a certain minimum angle, in order to be separately visible, and when black lines are drawn near each other the white part between

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must subtend a certain minimum angle if they are to be seen as separate lines.

In looking at printed letters or a line drawing or process block, such as the illustrations in a paper or magazine, the eye wanders about over the whole area, and if the lines are sufficiently wide and the difference in brightness is sufficient between the adjacent parts, viz., black line and white paper, the mind will interpret these various retinal impressions and integrate them into a complete picture or word.

This integration is, however, dependent upon another important and peculiar property of the retina, viz., the persistence of vision, in virtue of which an impression made on the retina lingers for about the tenth part of a second after the light stimulus is withdrawn.

Also, there is no doubt a purely mental persistence in the form of a memory of visual impressions.

Learning to See.

Hence, as the eye wanders over a picture, each of the retinal impressions gathered from a very small patch of the whole image is woven in with all the impressions to give a resulting mental perception which we call a total visual impression. The mind has to learn to interconnect this with the impressions brought in by other senses, such as hearing and touch.

We all have as babies, therefore, to learn to see, and when we are grown up we forget all that is involved in it. I remember reading in some novel (I forget the author) of a child born blind, but who had other senses normal. She was educated by touch and sound. Thus she could tell the dog from the cat because she had learnt to associate the sound of the word "dog" with a certain feel of rough hair, and "cat" with a sensation of smooth fur.

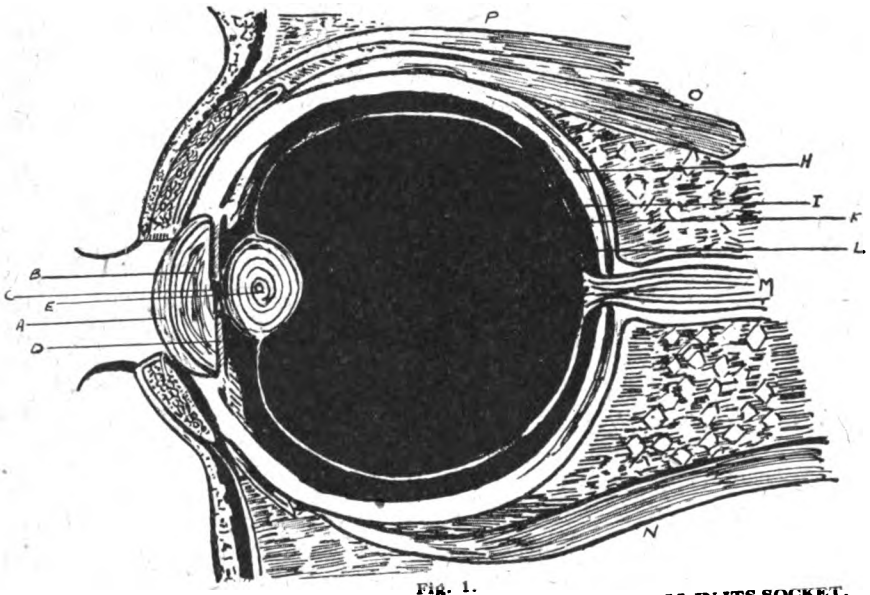

Fig. 1.

REPRESENTATION OF A VERTICAL CUT THROUGH THE EYEBALL IN ITS SOCKET.

P O N, muscles of eyeball; A, cornea, which closes the front of the anterior chamber B, which is filled with aqueous humour, and the back wall of which is formed by the curtain of the iris D. In the middle of the back wall is the opening of the pupil C, through which is seen the lens E. Behind the lens is the posterior chamber L, filled with vitreous humour. Entering the eye from behind is the optic nerve M, which is distributed to the retina K. The posterior wall of the eye shows from within outwards the image-forming retina, the dark choroid with blood vessels I, and the firm protective sclerotic H.

After a time, when she was a little grown up, a surgical operation gave her eyesight. She had then to learn to see. She could not at first tell the dog from the cat merely by looking at them. She had to be allowed to touch them as well. After a time she learnt to interpret her visual impression and say which was the dog without handling the animal.

It is clear, also, that the extent of the persistence of vision differs in various persons. In some the retinal impression or stimulation lingers a little longer or a little shorter than in other persons.

Now the phenomena of the television image and its recognition is different in many respects from that of looking at a static picture, line-drawing or photograph, which is all there all the time and, so to speak, awaits inspection at all parts when, and as often as, the eye roves over it. The television image, however, is not there all the time. In fact, it is not there at all, except for the persistence of retinal stimulation and the power of the mind to gather up and integrate into one complete whole all the several elementary impressions made by a rapidly moving spot of light which changes its colour or brightness as it flies across the field of view.

The Personal Equation.

Accordingly there is a large element of personality or, as astronomers say, of the personal equation in television. But on the other hand there are important factors which depend on the apparatus itself.

Let us consider for a moment what is taking place in viewing a television of, say, a human face by the travelling-spot method of Mr. Baird, which is the only method so far brought to practical success. Let us suppose the subject to be a girl with well-marked black eyebrows and hair, and a very fair or white complexion.

When the scanning spot of light is moving over the black eyebrow, little or no light is scattered from that spot, and, therefore, no current is produced by the photo-electric cells and no glow takes place on the plate of the receiving neon tube. In other words, a black patch is received.

When the scanning spot passes off on to the white forehead, then there is much light scattered, and a considerable glow of the neon tube, giving a bright patch in reception.

Suppose the spot of light is not very small. Let us take an extreme case, and suppose it to be a quarter of an inch in diameter. Then when the spot passes off the eyebrow there will be a moment when it is partly on the black eyebrow and partly on the white forehead. The result will be a partial scattering of light and a partial glow in the neon tube. It is easy then to see that the result of using a very large scanning spot of light would be to blur or shade off, gradually, parts of the television image which correspond to very sharply marked contrasts in the object itself being televised. In other words, it would not be good television.

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It will be obvious, then, that for good television by the spot method it is essential to have a very small and brilliant scanning spot with very great and steady illumination or brightness of light. Also if an image of a moving object is formed by a lens or mirror it must be of large size to gather a great deal of light. As a necessary consequence, the size of the windows in the revolving discs both of transmitter and receiver must be relatively small.

Suggested Method of Testing.

The question then arises: How shall we test the performance of any given television apparatus? I venture to make the following suggestions.

When you go to have a pair of spectacles or eyeglasses fitted to you to improve your vision, the optician or occulist does not bother you with mathematical formulæ. What he does is to put in front of you, about twelve inches or so from the eyes, a large card with letters or sentences printed on it in various sizes of types, and he asks you to say which is the smallest size of type you can read easily, first with one eye shut and then with the other eye shut. From those data he is able to select the proper lenses for your spectacles.

In printing offices the various sizes of type used are known by different names, such as "pearl," "brevier," "pica," etc., although an American custom is to denote them by "points." Thus, pearl is five-point, nonpareil is six-point, minion is seven-point, brevier is eight-point, etc., up to two-line pica, which is twenty-four-point. Larger sizes still are used in title pages, and in handbills.

Suppose then a number of cards prepared each with a short sentence on it in these various sizes of types as in our appended example (see Fig. 2). Let each of these cards be numbered and passed in succession before the television transmitter, and let an observer at the receiving end be asked to say which is the smallest size of type, or which number he can easily read by television transmission. Then that test would fairly indicate the perfection or want of perfection of that particular television apparatus when used by normal eyes.

It is hardly necessary to say that the observers who make this comparative test must be those who have normal vision and not those who have any defect of eyesight. All the same a short-sighted or long-sighted person sees the television image perfectly well when assisted by his usual eyeglasses or spectacles.

If a sort of committee or jury is empanelled to report on a certain television apparatus then any differences of opinion must be settled by the majority.

Perhaps when television is rather more advanced an International Convention on television will be necessary to settle exactly the tests to be applied and the standard to be reached by any apparatus to be supplied to the public.

There is, however, another personal factor involved and that is the difference in persistence of vision for various observers. Mr. Baird tells me he has noticed great differences.

When a particular television apparatus with discs running at about 200 r.p.m. is viewed by some people, they will see only a quickly moving spot of light. Other persons at the same time will see a complete image. This is obviously due to variation in persistence of vision.

If it were possible to destroy this persistence altogether, there would be no possibility of achieving television by the spot method.

There will, obviously, be an optimum or best speed of revolution of discs for each particular television apparatus, and one which suits the average eye. We may have one day to test people for persistence of vision just as we have now to test railway men for colour (red—green) blindness.

(1) Matter, which is a collective name for material substance, has been defined in many ways. J. S. Mill defined it as the permanent possibility of sensation.

(2) It has also been defined as that which occupies Space or as the vehicle of Energy. Its fundamental quality has been considered to be Impenetrability, which means that two samples of it cannot occupy the same space at the same time.

(3) These definitions, however, do not carry us very far, and are, in fact, little more than equating one unknown quantity to another.

(4) Experimental science has, however, made progress where Philosophical enquiry halts. We have been able to learn some very important things about material substance.

(5) In the first place there are certain kinds of substance from which we cannot extract any different kind of substance. We shall see presently within what limits this statement holds good.

(6) Thus from Water we can obtain two gases, viz., Hydrogen and Oxygen, but from these latter we can get no chemical substances different to themselves. These are called, therefore, elementary substances.

(7) All other substances are made up of mixtures or combinations of these elements, just as every word in the English language is made of a collection or group of some of the 26 letters of the alphabet.

Fig. 2.
Suggested form of test card which might be used for comparing the reproducing abilities of different television systems.

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All these different personal peculiarities of vision are not at present amenable to exact numerical definition and hence it is, in my opinion, impossible yet to frame mathematical formulæ for television apparatus. But it will no doubt come in time. In the early days of wireless telegraphy we none of us knew anything about the measurement of wavelengths or electric fields, due to radiation, but now we can measure both these quantities very accurately.

A Practical Test of Efficiency.

The tests above suggested, viz., the degree to which any given television apparatus can transmit to a distance clear images of printed words in type of various sizes, would provide a practical test of efficiency. There is then the question of colour to be considered, and especially of the steadiness of the image due to "hunting" or want of perfect synchronisation of the rotating discs in the transmitter and receiver respectively.

This is a very important matter, because the image as a whole must be steady and without flicker if the eye is to be capable of examining it and enjoying the appearance. There is, of course, a special set of difficulties which come in when the transmission between the transmitter and receiver is by means of electro-magnetic waves, such as those due to "atmospherics," ship Morse, fading, or other disturbances which, however, equally afflict music or speech broadcasting.

These we cannot yet entirely eliminate or define. A great deal depends on the wavelength which can be used. Thus, several hundred miles from Daventry we can pick up the broadcasting of music or speech very well on the Daventry long-wave 5XX, but the short-wave 5GB is of very little use to those who live on the South Coast of England on account of the perpetual disturbance by ship Morse and spark-stations, which cannot be eliminated by any tuning out.

For these reasons quantitative work in the case of television is yet premature. The test of a pudding is proverbially said to be in the eating, and we may also say that the test of a television apparatus is in the "seeing." If we can see what we want to see it is all right and good enough for use.

A Vision (Tele-) of a Hat

By NOËL SWANNE

"I WANT £3 16s. 3¾d.," said Marjorie.

I got out my cheque book and obliged. I am like that, and . . . well, why waste time, as well as money?

"What is it for?" I asked, out of curiosity. I had no worries about the cheque. I have lots more cheques, and a few more or less don't matter. Besides those bank clerks ought to earn their living. They get an easy time with my account. It is so simple. All they have to do is to put R.D. on the cheque, and the transaction is over, and they can have another Bank Holiday.

"A hat," replied Marjorie.

"A hat! Another one!" I growled.

"Of course, you didn't think I was buying the same one twice, did you?" she said.

"But what do you want another one for?"

"Television," was the reply.

I knew there was a snag in it somewhere. I shrugged my shoulders as I had seen a Frenchman do on the platform at Victoria, and said things *sotto voce*. (See Lesson 2, *Italian Without Tears*.)

"Mrs. Marningwell has a friend who is a prominent member of the Television Society," said Marjorie. "She is arranging to take me to see a demonstration. There will be quite a number of important people there. I shall be very nice to the demonstrator and get him to televise me—if that's what you call it."

"I don't see why a new . . ." I began.

"You don't imagine that I am going to let all those people see me like that in that old hat I had last month, do you?"

"They will ask you to remove your hat," I said. "Hats don't televise very well."

"Oh!" said Marjorie.

The trouble with me is this craze for thoroughness. If only I had shut up then I should never have had that letter beginning, "Your cheque has been returned . . ."

"Owing to the frequency of the scanning device," I explained, "and in order that the correct number of electrons may be liberated in unit time, it is absolutely essential that . . . er . . . no interference shall be caused . . . er . . . by hats."

"Oh!" said Marjorie.

"Therefore you will see the advantage of going in a small hat which you can easily remove," I continued. "A hat like that last one of yours would be ideal."

"Then I shall sit there with my hat off, shall I?"

"Yes, of course," I hastened to confirm.

"With my hair blowing all over the place!"

"And very beautiful the golden tinges in it will look. The little electron things love golden tinges. You will be a great success."

"I shall," said Marjorie. "How many times does seventeen and sixpence go into three pounds sixteen and threepence three farthings?"

"Eh?" I ejaculated.

"Three pounds . . . sixty shillings and sixteen is . . . er . . . seventy-six, and . . . yes . . . that is about four . . . two on each side . . . and a bit over for tea."

"Bogey-bogey!" seemed to be the only sensible reply.

"That is the best of having a husband who knows all about these things," said Marjorie smiling. "Now, if you had not saved me, I should have wasted all that money on a hat."

"I know, dear," I said. "Perhaps I had better tear that cheque up, now."

"But I want it," protested Marjorie.

"I thought you had realised that you do not need a hat," I said.

"I do. So I shall have four permanent waves at seventeen and six each instead, two on each side; and your dear little electrons can roll down one side and up the other. It will be most exciting!"

Would any gentleman like to lend me ten thousand pounds on my note of hand only? I shall need it if this television is going on.

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Television Progress in Germany

By Dr. ALFRED GRADENWITZ

Great interest is being taken in television in Germany at the present time. In the following article Dr. Gradenwitz describes the latest achievements of one of the German experimenters, Dr. Karolus. Dr. Gradenwitz has witnessed demonstrations of the Baird system both in London and, more recently, in Berlin and is therefore in a position to compare results accurately.

WHEN the Baird engineers, a short while ago, came to Berlin, at the request of Dr. Bredow, Secretary of State for Wireless Broadcasting, in order to demonstrate the possibilities of their system from German transmitters, they found themselves face to face with two rivals fighting each other with the same ardour as they would oppose the common adversary.

Dénes *v.* Mihály had for some time been testing his tele-cinema from the Witzleben transmitter, and while the ether around Berlin resounded with these experimental transmissions the Berlin Press was echoing with records of his plans and claims. Nay, when the television laboratory just installed at the *Voxhaus* headquarters of the Berlin Broadcasting Company had, because of more urgent work at home, to be closed for a few weeks, all the Berlin papers with one accord seemed to take it for granted that tests of the British system had been meeting with unsuspected difficulties and had definitely to be given up. With all this newspaper comment, the wish had, of course, been father to the thought, for at the moment of writing the Baird Company's chief engineer has just come back to Berlin in order there to resume the tests temporarily discontinued.

The Activities of Karolus.

Dr. Karolus, Professor at Leipzig University, the other exponent of television in Germany, who, in co-operation with the Telefunken Company, has developed a highly efficient system of facsimile telegraphy, had been, during this time, continuing his television tests in absolute secrecy.

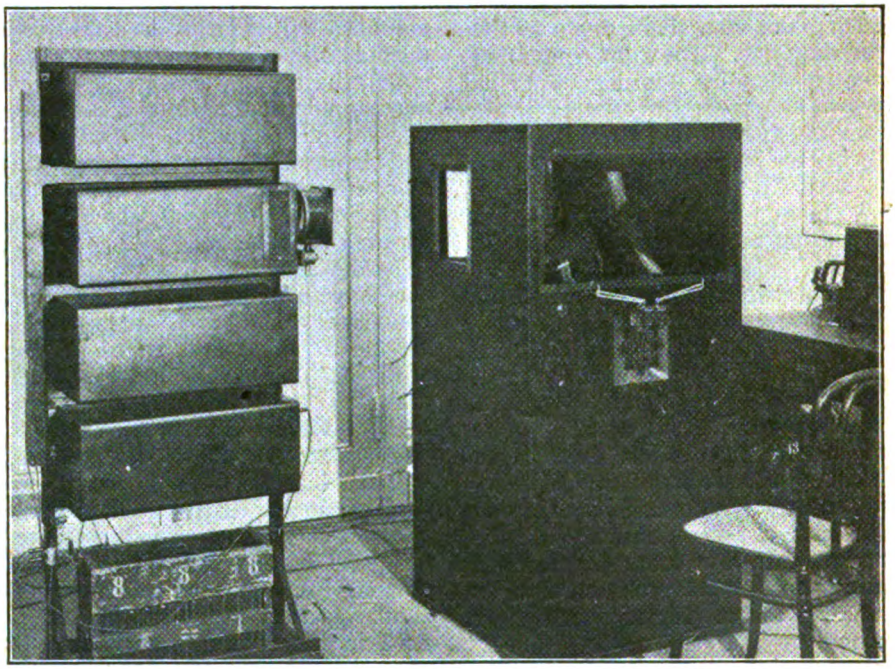
His first demonstrations at the last Berlin Radio Exhibition, where the transmission of shadowgraphs was shown, had, of course, been slightly disappointing both to him and to the public, and the inventor therefore had made up his mind not to give any further demonstration before a decided advance was achieved.

This moment has now arrived, for at a recent Press demonstration given by the Telefunken people the present stage of Karolus television was for the first time exhibited to the public.

Though the achievements of Karolus (who no longer confines himself to the transmission of shadowgraphs, but shows real television of one person) **are of undoubted interest, they are as yet far behind those of the Baird system.** If so serious a scientist as Prof. Karolus and a firm of the scientific and industrial standing of Telefunken nevertheless are advancing claims of superiority over any other system—in fact, the statement just issued to the Press disposes in a rather high-handed way of the endeavours of all other inventors, drawing attention to the "daily booming of what is termed their definite solution of the Television Problem"—this is obviously due to the fact that neither the Professor nor his collaborator, Dr. Schrœter of the above wireless company, has any first-hand knowledge of Baird's achievements.

The Transmitter.

Instead of the revolving disc



Dr. Karolus's Transmitter.

On the right is seen the recording apparatus and mirror wheel from which the beam of light is thrown upon the person being televised. The mirror wheel and driving motor are enclosed in the right-hand casing, whereas the left-hand frame contains the photo-electric cell and associated amplifiers.

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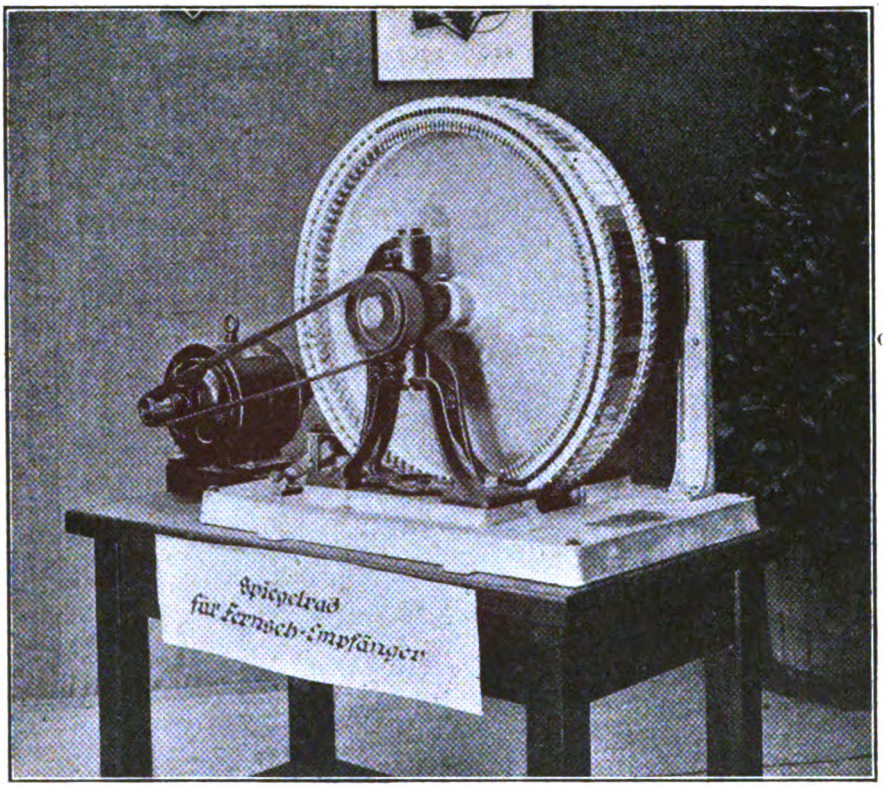


The revolving mirror wheel used by Karolus in scanning and reconstituting pictures at the transmitting and receiving ends.

employed by Baird, Prof. Karolus uses for scanning the original object or person a wheel carrying at its periphery a number of small mirrors (fifty in the present case), each of which is set at a slight angle to the preceding one. The light emanating from a steadily burning lamp is thrown upon these revolving mirrors from which it is cast back upon the object to be lighted. The beams reflected from the object eventually fall upon a photo-electric cell, converting the various shadings into variable electric impulses. This scanning wheel was described in our October, 1928, issue.

The photo-electric cell developed by Telefunken is of annular shape, the beam of light passing through its central opening, and is said to be sufficiently free from inertia to respond without any material delay to, say, a succession of 100,000 stimulations per second. In the present case a picture decomposed into 2,500 elements is scanned in its entirety about fifteen times per second.

Kerr Cell for Reception.

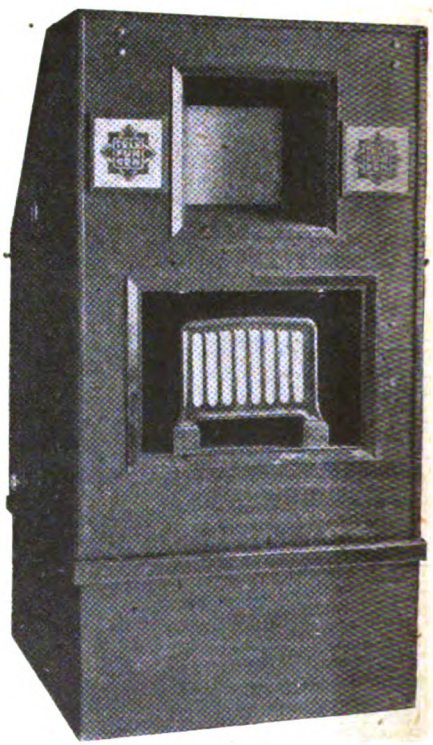
The variable electric impulses coming from the photo-electric cell are made to modulate the electric waves emitted from a short-wave transmitter. At the receiving end the low-frequency impulses of the wireless receiver will, after due amplification, control a Kerr cell (also described in our October, 1928, issue), the device used to re-convert current fluctuations into a sequence of variable luminous intensities. This is based on what is termed the Kerr effect, viz., the electric double refraction of polarised light passing through nitro-benzol.

As developed by Karolus, it takes the shape of a translucent miniature condenser filled with nitro-benzol, the electrode plates of which are fed with the amplified low-frequency impulses. This arrangement will allow a variable amount of light to pass in accordance with the actual electric tension at the Kerr cell, thus producing a sequence of luminous dots corresponding to the various elements of the original object or person. A revolving mirror wheel similar to that of the transmitter is used in the receiving apparatus to reconstitute the original picture, by casting the reflected light upon a projection screen of 30 by 30 cms. (12 by 12 inches). It is claimed that this method enables the intensity of the source of light to be increased at will, the more so as the Kerr cell will control any luminous intensities.

Synchronising Arrangements.

The synchronising device employed by Karolus is based upon the use of entirely self-contained local contacters, viz., tuned-fork buzzers, the frequency of which is kept constant by keeping their temperatures at constant values. The current supplied by the tuned-fork buzzer is, after due amplification, supplied to a small synchronous motor mounted on the shaft of the motor driving the receiving mirror wheel.

Though Prof. Karolus's original receivers, as shown at the last Berlin Wireless Exhibition, have now been much simplified and reduced in cost, they are still rather expensive. Moreover, the inventor himself is emphasising the fact that his method could not be adapted to wireless broadcasting before short waves—preferably 50 to 100 metres—are released for television purposes.



The Karolus Television Receiver.

The received image (a foot square) appears in the upper square opening, below which is the loud speaker. A serious drawback to this instrument, from the public's point of view, is its price, which is stated to be £400. Dr. Gradenwitz, in this article, says that although "the achievements of Karolus are of undoubted interest, they are as yet far behind those of the Baird System."

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NOTES ON OPERATING A BATTERY ELIMINATOR

By W. C. FOX

This month our contributor gives some further very valuable hints on the adjustment and operation of the battery eliminator which he described in our last issue.

I HOPE those readers who have built a battery eliminator on the lines of the one described in last month's issue of TELEVISION have got it going satisfactorily without trouble. If all the connections were made correctly, and the various points mentioned were observed, it should be working perfectly.

Presumably, its first use will be to supply the needs of a wireless set. No apology is necessary here for mentioning a wireless receiver, for if television signals are to be received at all by the vast majority of experimenters, it will be by means of the wireless set that they will come.

If, therefore, having completed an eliminator and hooked it up to a wireless receiver things don't work, don't assume that the eliminator is at fault, that a condenser in it is broken down or that the choke is not working as it should. In all probability the set is faulty. Many wireless sets, while they will work on batteries or accumulators, more or less normally, betray any weaknesses they may have, in the way back couplings, when put on to the mains.

This is mentioned in the hope that it may save some reader from the author's unhappy experience of pulling his eliminator to pieces to find a fault which existed in the wireless receiver!

It helps considerably if one has a reasonably good milliampmeter when adjusting an eliminator, for, knowing the current requirements of each valve, the voltage-dropping resistances can be adjusted until the required current is flowing in each plate circuit.

The average high-reading volt meter is *not* suitable for measuring plate voltages when an eliminator is used, for as a rule the volt meter takes more current than many of the valves. Its demands create a voltage drop and so give a false low reading of the actual voltage passing to the plate.

The only suitable instruments are a very high resistance volt meter of the order of 4,000 ohms or more, or an electrostatic volt meter. The latter type of instrument takes no current at all, and depends for its action on the fact that oppositely charged bodies have an attractive effect on one another. In construction an electrostatic volt meter is a variable condenser in which the moving vanes are attached to a pointer and are drawn into engagement with the fixed vanes in strict proportion to the charge which they carry. Such instruments can be

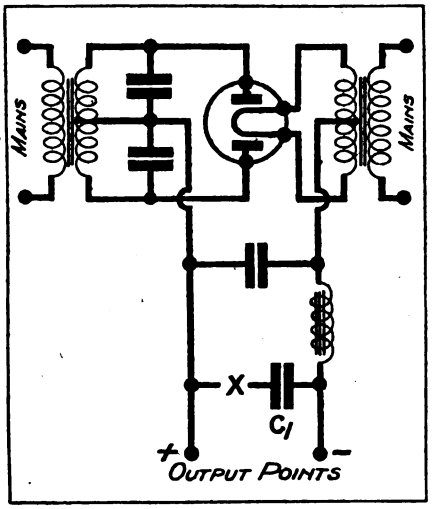

Fig. 1.

made to read as low as 5 volts, but they have the disadvantage of requiring a very steady mounting and bearings as friction-free as science and the instrument makers' skill can make them. Naturally, they are costly, and when made for lower readings are of the electrometer type. Incidentally such instruments can be very simply made.

The difficulty, however, can be overcome quite easily and readings of voltages secured by comparison.

Suppose it is required to know the plate voltage of the detector valve.

The actual filament voltage applied to this valve in use is read by an ordinary volt meter *at the valve holder.*

A test panel is rigged up with a valve holder. The valve is placed in this and the filament voltage adjusted to that in the set. Then, with a milliampmeter in the plate circuit of the valve, known voltages from a good H.T. battery or other dependable source are applied and milliampmeter readings taken. If these are plotted against the voltages, one gets a graph from which intermediate voltages can be read.

Each valve in a set can be calibrated in this way, care being taken in each instance to reproduce the filament voltage conditions, and any other circuit arrangement affecting the valve, such as grid bias.

With the eliminator in use it is then only necessary to read the milliamp current in any plate circuit and refer to the appropriate graph to know what the voltage is. This method works quite well if care is taken to reproduce conditions on the test panel exactly as in the circuit. When the positives of the filaments are joined to the negative of the H.T., however, results are not so reliable.

So much for voltage measurements. Probably motor-boating will be the most troublesome effect that constructors will experience. Two methods of dealing with this have already been given—a third also can be tried. As is generally known, motor-boating is caused through a high resistance common to all valves acting as a coupling between them and feeding energy back from one to another. In an eliminator this resistance is provided by the choke and the smoothing and voltage dropping circuit. It can often be cured by inserting a resistance at the point marked X Fig. 1.

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A rheostat of 800 ohms is a suitable value, but it will almost certainly need to be adjusted until the critical position is found. Another method is to split up condenser C1 into a number of separate units. This arrangement is shown in Fig. 2. To mention all the possible causes of feed-back or motor-boating here would require more space than is

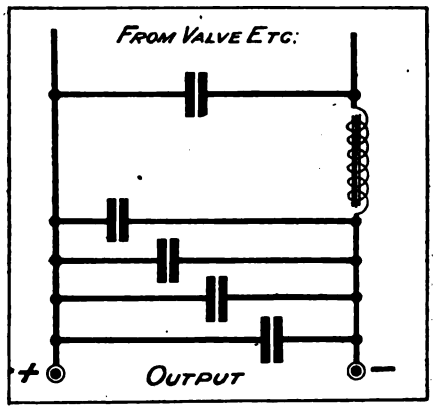


Fig. 2.

available; they are so numerous; but it may be of interest, and perhaps helpful, to mention an obstinate case that seemingly defied all efforts to cure it.

It was caused by the use of voltage-dropping resistances of too high a value. When adjusting the eliminator a critical point was reached at which one or more of these resistances was acting as a very high value leak and slowly charging its associated smoothing condenser. When the condenser had a sufficient charge to work the set, things began to move, only to die away as the condenser charge was used up, when a silence ensued until the next charge has accumulated. This cycle, of course, took place fairly quickly, and bore all signs of motor-boating. Lower values of voltage-dropping resistances in the eliminator cured it.

While the compression carbon type of resistance mentioned in previous articles is quite suitable for voltage dropping when there are not likely to be very frequent adjustments, they are a nuisance when the eliminator is used for a variety of purposes requiring different voltages, for the same point can rarely be found, while in addition considerable use is likely to make them noisy or lead to "packing."

In such special circumstances, an adjustable high value wire wound rheostat is desirable. Such a one is the Truvolt. It is positive in its action and can carry far more current than is ever likely to be required. Once installed, too, the panel can be calibrated. This is possible, as unlike the compressed carbon type, only about a quarter of a turn of the control knob takes the resistance from nil to its full value. Adjustment positions, once marked, can be returned to with certainty.

When testing and adjusting an eliminator it is advisable, after switching on, to wait a few moments for things to settle down and warm up to their work. The rectifier valve does not at once give its full emission, nor does its filament heat up as soon as the current flows through it. This may seem a trifling point, but it is mentioned so as to prevent readers imagining a fault where none in reality exists.

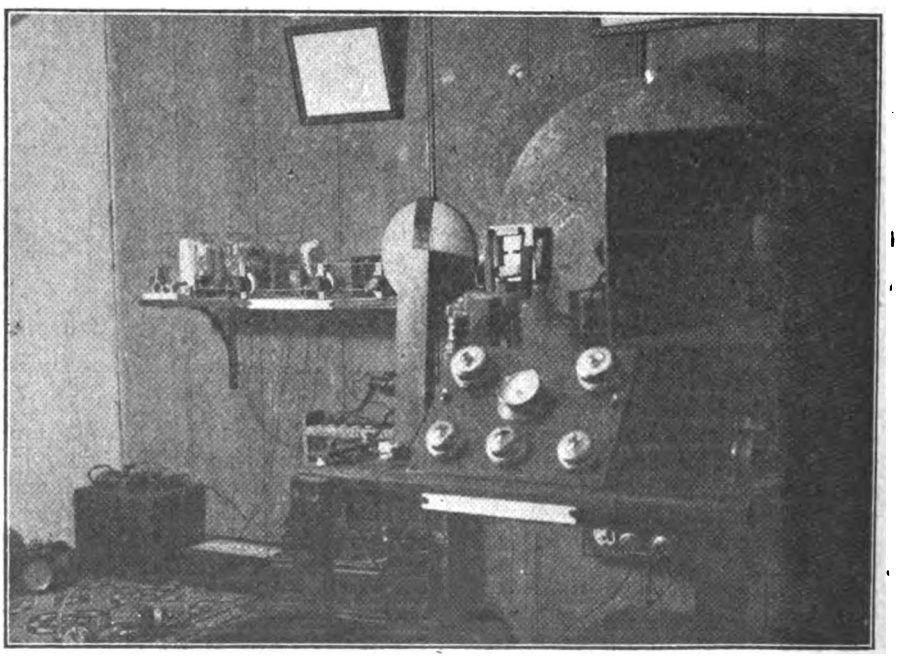
Charged Condensers.

On the other hand, when switching off, if an Ediswan valve is used, a faint blue glow may be noticed around the plates. This possibly puzzling phenomenon does not indicate a leak through the transformer from the mains, but is merely due to the condensers getting rid of some of their charge through the valve.

Speaking of charged condensers, it is a good plan to keep a short length of insulated wire handy when adjusting or experimenting with an eliminator, and before putting one's hands inside it after switching the mains off, or, in fact, touching any of the bare metal parts, short the full voltage terminal to the negative, once or twice. On the first contact there will be a nice big fat noisy spark as the condensers discharge. Subsequent sparks will be smaller. When there is no spark on shorting, it will be quite safe to handle anything on the eliminator. Neglect of this simple precaution will, sooner or later, bring its own punishment in the shape of a very unexpected and nasty shock, for condensers, particularly high value ones, seem to be capable of administering a peculiarly virulent and salutary type of shock.

When adjusting the various voltage tapping points it is advisable to bear in mind that a heavy call for current on one point will cause a drop in voltage at all others, so that a slight readjustment all along the line may be necessary. This is due to the fact that only a definite limited wattage can be drawn from an eliminator, as explained in the first article on the subject.

Once installed, an eliminator should work as reliably as the electric light, and with no more trouble.



Television Experiments in Guernsey.

There is a very keen interest being taken in television in the Channel Islands, and the above photograph shows the shadowgraph machine constructed by one of our readers, Mr. E. Baker, of South Side, St. Sampsons, Guernsey. Mr. Baker, who is an Associate Member of the Television Society, had to overcome many difficulties due to fluctuating mains before he achieved successful results.

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TALKIES *versus* TELEVISION

By CYRIL SYLVESTER, A.M.I.E.E., A.M.I.Mech.E.

Many people have asked us recently whether television has not arrived too late, and whether the speaking film will not entirely take the place of television. The "talkies" and television are two totally different things, as our contributor points out in the following article, in which he explains the special appeal which television has been designed to make, which appeal he thinks will prove much stronger than that of the talkies, from the point of view of entertainment value.

"HAVE you been to the Talkies?" is a question frequently to be heard in these days of talking pictures.

Talking pictures concern the public; the general public are interested in them, so the question is a natural one. It is a much different question to that which may be heard when two scientific men are discussing talking pictures. The question would be: "What do you think of the Talkies?" The question provides an easy way to discussions of light and sound, the conversion of sound waves into light waves and *vice versa*, amplification, loud speaker design and acoustics, etc.

In discussing these intricate subjects it is hardly possible to keep strictly to definite lines; the result is that arguments are deflected and go off at a tangent. I will give you a case in support of this.

A few days ago, not many yards from where these lines are published, I heard two men, of science discussing talking pictures. The tangent was reached when the question was asked: "How do you think talking pictures will affect television?" The reply was: "Television has come too late. Talking pictures have got a 'grip' on the public. Who will fiddle about with a television set when they can be comfortable in a warm, cosy cinema theatre?"

Now these two gentlemen are old friends of mine and, on some subjects, I respect their opinions. In connection with the above conversation, however, I must say (and I hope they will forgive me when they read these lines) that they are talking through their hats. My opinion is that television will seriously affect the patronage of talking pictures in the future. This not only because of the inconveniences which one must submit to in order to see a film, but because television will provide the better entertainment. I will endeavour to substantiate my opinion.

The Birthplace of TRUE Television.
22, Frith Street, Soho, London.
On the third floor of this building Mr. Baird first achieved true television in October, 1925. Later, some forty members of the Royal Institution attended a demonstration here. The laboratory was so tiny that while parties of six at a time witnessed demonstrations, the others had to remain on the stairs and landings, which were narrow and draughty. These small premises were occupied by Mr. Baird from August, 1924, to February 1926.

In the first place home attractions will always predominate in the recreation world. The only reason why one goes to a theatre to see a drama is because it is not possible to stage a play in one's home; it is a case of Mahomed and the mountain.

Again, considering a different form of recreation, does the man who owns a billiard table go round to an hotel or saloon for his games of billiards? He does not! What he does is to invite his friends round to play with him; in this way the hotel or billiard saloon must lose patrons.

One only has to think of the advent of wireless to realise the hold that home recreation has upon the general public. Of the many millions of wireless sets sold in the world it is safe to presume that, in a large number of cases, listening-in is preferred to other forms of recreation, among which must be included cinema talking pictures. In many cases a person who owns a wireless set goes to see the talking films, but he does so only because, at the moment, he has nothing else better to do. He would, indeed, be a very brave man who would venture to predict that when televisors are readily obtainable, and can be attached to an existing wireless receiver, the wireless enthusiast would go to see a talking film when *he will be able to see them* in his own home. It simply will not be done.

It is not a case of television coming too late, but of talking pictures coming too soon. Talking pictures in the past (and I would point out that the talking picture is not new by any means, by many years) did more than any other form of recreation to create an appreciation of home recreation. I am not

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referring to the talking picture as we know it to-day; it has been greatly developed.

It is not many years ago since the father of a family produced and operated his own talking pictures. Often the screen upon which the picture was projected was a white window blind. The "arc" was an ordinary paraffin lamp and the pictures were in the form of shadows produced by various objects placed between the lamp and the screen. The objects were many, according to the ability of the producer. Those who were not too dexterous were content to produce, by means of the fingers and hands making suitable motions, rabbits, ducks quacking and dogs barking, etc.

The cleverer producers, with the aid of various cut-outs, would stage a play. I have seen a play performed on the screen with appropriate vocal accompaniment, by means of cut-outs of figures, houses and the hands of one or more persons. These home shows were very popular; so much so that none of the family would think of going out to any other form of amusement on "show night."

If comparisons are to be made between talking films and television let us be open-minded about it. Let us consider both from the principal view-points.

To see a talking film, for instance, one has, as a rule, to wait in a queue, and this in all kinds of weather. Managements of some cinema theatres realise the inconveniences of patrons and, in wet weather for instance, they provide them with umbrellas. Often the tail-end of a queue is turned away because the whole of the seats are occupied. Then there is the inconvenience of travelling in inclement weather, and the cost of travelling when patrons reside at some distance from a theatre. Assuming one is fortunate enough to obtain a seat what is the quality of the entertainment?

At the best, a talking film is but "canned" sound and sight. It consists of a film, an ordinary film, with mechanised sound projected into the theatre through loud speakers to produce the illusion of life or movement. It is a reproduction of something which occurred hours, days, weeks, or perhaps months before it is projected upon the screen. Even with topical events some time must elapse before the event is shown, in the form of a talking picture, to patrons of a cinema theatre. Often, especially with news items, the novelty is stale because photographs, with suitable explanatory text, have appeared in the ordinary Press.

This is not the case with television. Every owner of a suitable wireless receiver will be able to *see* events as they actually occur. This applies not only to the broadcasting of a play or opera, but to all phases of sport and social life. How much better, for instance (to quote a recent sporting event), it would have been if the admirable description or commentary of the Oxford and Cambridge boat-race broadcast by the B.B.C. had been supplemented by a "view" of the race as seen by the televisor? The panorama of the boats passing under Putney Bridge, of them approaching Mortlake brewery, of Cambridge drawing gradually ahead, would have kept many at home to see-in and listen-in.

In these comments on the Talkies *versus* Television I have been very fair to all associated with the film industry. Good actors are employed in the making of a film to ensure that it shall be a box-office attraction. I have referred to long queues in all kinds of inclement weather; to efforts of managements to make patrons comfortable. In other words, I have emphasised the popularity of the "Talkies."

When, however, we all have our seeing-in sets installed I will have quite a different story to tell.

The Birthplace of Noctovision and Phonovision.

In February, 1926, Mr. Baird moved from Frith Street to the top floor of this building, Motograph House, Upper St. Martin's Lane, London. During his tenancy of these premises he invented noctovision and phonovision. He also built the world's first television broadcasting station, 2TV, the masts of which can still be seen on the roof. This building was the first registered office of the Baird Television Development Company, which was floated in April, 1927. More space being required, Motograph House was vacated at the end of that year.

Honour for Prof. Appleton.

We have pleasure in announcing the award to Prof. E. V. Appleton, F.R.S., of the Morris Liebmann Memorial Prize for 1928. This prize is awarded annually by the Institute of Radio Engineers for the most outstanding contribution to the advancement of wireless knowledge during the current year.

Professor Appleton, who is Wheatstone Professor of Physics at King's College, London, has been engaged for many years in the study of the electrical properties of the upper atmosphere.

Hitherto it had not occurred to anyone that there might be more than one Heaviside layer. Professor Appleton's researches, however, indicate that there is a second or outer layer situated outside the first, or inner, layer. Systematic measurements have placed the height of the first layer above the earth at 98 kilometres, and that of the second layer at 226 kilometres. These results have recently been verified by independent observations conducted in America.

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Photo-Electric Currents in Gases

By H. WOLFSON

From previous articles on Photo-electric Cells which have appeared in these pages we have learnt that many types of photo-electric cells are filled with various gases at low pressure. In the following article our contributor discusses the effects which various gases have on the passage of photo-electric currents.

IN our previous discussions of photo-electric phenomena we have seen that many of the latest types of photo-electric cells are filled with one or other of the inert gases, at a pressure which is chosen in order that the cell shall give the maximum output possible. In order, then, to design new and improved cells, it becomes essential that we should study in detail the photo-electric current in gases at various pressures.

In an earlier article* it was shown that the photo-electric current in a high vacuum consists of a stream of particles of negative electricity, which we know as electrons. In another article we considered the nature and properties of cathode rays (January, 1929) which have been shown to be made up of a fast-moving stream of electrons, whose velocity depends on the pofential at which the tube is operating. In the latest tubes this velocity is about 90 per cent. of the velocity of light, which we know to be 3×10^{10} cm. per second. Photo-electrons, on the other hand, travel much slower than this, their initial velocity rarely exceeding 10^8 cm. per second.

The Starting Point.

Our starting point in this discussion is the early discovery of the pioneer worker, Hallwachs, that a negatively charged plate loses its charge when illuminated by ultra-violet light. This can only be explained by assuming that electrons are liberated from the metal plate in air as well as in a vacuum. At ordinary atmospheric pressure the electrons readily form nuclei around which molecules of the gas collect to form heavy complexes, or negative ions, which naturally move with comparatively small velocities when placed under the action of an electro-static field.

Investigations along these lines naturally lead to the thorough unravelling of the subject, and Rutherford has measured the ionic mobilities of the various ions by applying an alternating electric field, and found the mobility or velocity under standard conditions (potential difference 1 volt per cm.) as follows :—

Air, which is a mixture of oxygen and nitrogen, 1·4 cm./sec.
Hydrogen, the lightest molecule known, 3·9 cm./sec.
Carbon dioxide, 0·78 cm./sec.

Ionic Mobility.

These figures being for atmospheric pressure, i.e. 760 mm. of mercury, further experiments were carried out with a view to establishing the relationship between the ionic mobility and the pressure. Like so many important results, a simple relationship was found to hold, namely, that the ionic mobility was inversely proportional to the pressure of the gas ; in other words, the velocity of the negative ions increases with decreasing pressure. This result is important, and should be borne in mind.

If the field under which the ions are moving is greatly increased, and the pressure be at the same time reduced to the order of a few millimetres only, the whole aspect of the problem is changed, and new considerations arise in the form of ionisation by collision. This has already been considered in my article on cathode rays, and my readers would be well advised to read through this article again in conjunction with the present one.

When the conditions are suitable the electron velocity is increased to such an extent as to produce ionisation by collision, which gives rise to both positive and negative ions. These ions, being of opposite charge, will move in opposite directions through the field, and by increasing the strength of the field to a sufficiently high value the positive ions, themselves formed through collisions, will bring about ionisation by collision, though the potential required for this is very little short of the sparking potential of the gas at the particular pressure.

In gas-filled cells, then, there are three possible sources of the photo-electric current : (1) Due to photo-electrons, liberated by the action of ultra-violet light ; (2) the current may be carried by negative ions, formed as indicated above ; (3) the current may be carried by ions, formed by collision.

Exactly what proportion each of these factors contributes to the total photo-electric current it would be difficult to say, as they vary with the conditions of pressure and strength of field. In a good vacuum, factors (2) and (3) must, of course, be absent, and the whole of the current is thus carried by the photo-electrons. Increasing the pressure tends to place more responsibility on the negative ions, so that the photo-electrons do not carry any appreciable proportion of the current at ordinary atmospheric pressure.

Ionisation.

As we have seen, with increasing electric field there is an increasing tendency for ionisation by collision to take place, and, as is well known, negative ions, or anions as they are sometimes spoken of, move to the anode, while the positive, or cations, move to the cathode. Thus we see that as the field is increased more current will be carried by ions. Modern cells are worked with a potential across the cell of a value so adjusted to give maximum sensitiveness, and important considerations of ionisation by collision, and the conduction of electricity by ions arise, and call for careful study.

Let us consider first the case of experiments in which moderate fields, insufficient to produce ionisation by collision, are employed. Stoletow has measured the photo-electric current from a metal plate, illuminated by ultra-violet light, the plate being placed in a vessel containing air at various pressures.

Stoletow's Experiments.

Light from a powerful arc lamp, after passing through a kind of diffraction grating formed by ruling lines on a silvered quartz plate, fell

*The Influence of Polarisation and Frequency on the Photo-Electric Effect, "Television," Sept., 1928.

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upon a silvered plate, whose distance from the grating could be adjusted by a micrometer screw. The diagram in Fig. 1, taken from the original

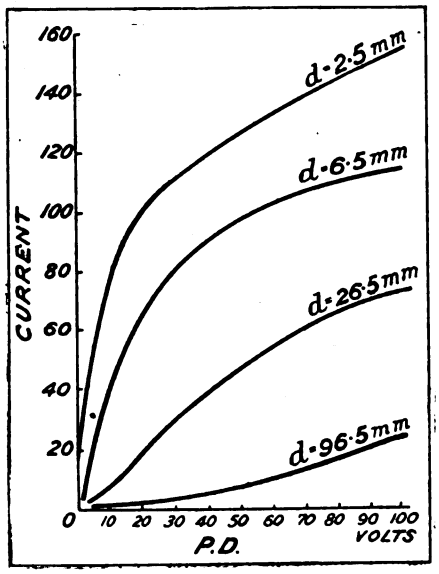

Fig. 1.
Showing the current for different values of electric field. The different curves were obtained by varying the distance *d* between plate and grating.

papers, gives the current under different accelerating potentials, while the different curves were obtained for different distances between the grating and the plate. It can be shown that the current i is the same for all distances d, provided that the ratio $\frac{E}{D}$ is constant, where E is the potential between the plates.

When, however, the pressure is reduced this relation no longer obtains and when the pressure is reduced there is no approach to saturation, though at very low pressures the saturation again appears. This led Stoletow to investigate the variation of the current with pressure, using a constant potential. At first, as the pressure is reduced the photo-electric current increases slowly, and gradually more rapidly as the pressure decreases. When the critical pressure p_m is reached the current attains its maximum value, afterwards diminishing towards a finite limit. The value of this critical pressure is given by the equation $p_m.d/E$=constant. The value of this constant depends, of course, upon the units employed, but for d in cms., p in mms. of mercury, and E in volts, its value is 1/372.

Saturation Values.

This state of affairs is illustrated in Fig. 2, each curve being obtained for a definite value of electric field. We see that the current is independent of the potential difference at low pressures; in other words, it is saturated.

E. von Schweidler has carried out experiments with an Elster and Geitel type of cell, and considers that three definite stages must be imagined in considering the relation between potential difference and current. For small P.D.'s up to two volts the current varies linearly with the potential. During the next stage, from 2 to 70 volts, though the current increases more slowly, it nevertheless does not attain saturation value. As soon as the potential rises above 70 volts, however, the current increases much more rapidly, and Fig. 3 is given to illustrate the three stages. The curve relates to an amalgamated zinc plate with a gas pressure of 17 mm., and is taken from a later paper of von Schweidler.

Varley has given a number of papers to the Royal Society of London, in which he describes a systematic examination of the dependence of the magnitude of the photo-electric current on the nature and pressure of the gas. A complete curve was drawn which gave the relation between the current and the potential for each value of the pressure. The source of light—an arc between iron terminals in an atmosphere of hydrogen—was chosen on account of its stability and constancy. In order to ensure that the intensity of illumination was constant separate observations were taken with a separate piece of apparatus during the course of the experiments.

Varley's Results.

An examination of Varley's results leads us to the same conclusions as those obtained some years previously by Stoletow, namely, that for a constant potential, if the pressure is decreased, the photo-electric current increases, reaches a maximum, and then diminishes towards a finite limit, which is more or less independent of the potential.

Similarly, the results of variation of current with potential difference, taken at a number of definite pressures, can be summarised by the curves shown in Fig. 4. It will be noticed that each curve corresponds to a definite pressure, and to aid in following out the process more easily I have numbered these in order of pressure, 1, 2, 3,. etc. Thus curve 1 is for atmospheric pressure, while curve 6 is taken at a pressure of 0·0019 mm.

Three Stages.

As before, this process takes place in three stages. At ordinary pressures the curve is almost flat, corresponding to saturation, but lowering of pressure is accompanied by a gradual steepening of the curve, till, in curves 3 and 4, Fig. 4, it will be observed that there is not the slightest suggestion of saturation. At this stage a small change in potential difference is accompanied by a large change in the value of the photo-electric current.

In curves 5 and 6 we see the approaching saturation, and at the lowest pressure of all we get a true saturation current, which in turn decreases with the pressure, till at a nearly perfect vacuum the current approaches a finite limit. It is in this third case that the mean free path of the ions becomes of the same order of magnitude as the distance between the electrodes. By mean free path we mean the average distance between successive collisions of the ions. When this state is reached the number of collisions occurring between the photo-electrons and the molecules of the gas becomes strictly limited, and as we have already seen a small potential gradient is sufficient to cause saturation.

Further experiments have been made by Varley with a view to determining the behaviour in other gases, such as hydrogen, carbon dioxide, etc. The results for air are

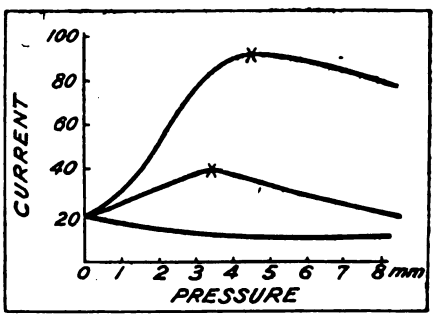

Fig. 2.
Curves showing the critical pressure *X* corresponding to maximum photo-electric current.

intermediate between those for hydrogen and carbon dioxide for all potential gradients up to those where ionisation by collision begins, carbon dioxide giving the largest currents. Ionisation by collision begins in hydrogen at a much lower potential than with the other gases, air or

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carbon dioxide, for which the potential gradient required for this ionisation is about the same, whereas the potential required for a spark discharge in hydrogen is little more than half this value.

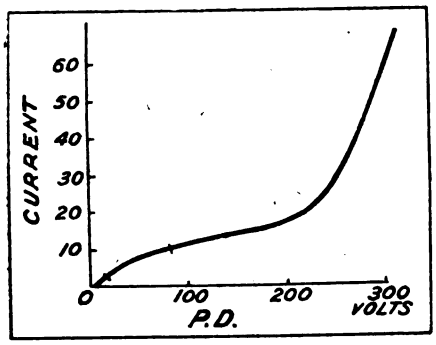

Fig. 3.
Showing the three stages imagined by V. Schweidler in considering the relation between the applied field (P.D.) and the photo-electric current.

The fact that all metals show a marked increase in the photo-electric current at or near the sparking potential was first demonstrated by Kreusler in 1901. Hertz, in his experiments, was unable to detect any difference in the photo-electric sensitiveness of a large number of metals, which he used as cathode in his experiments, and the results of Kreusler explain this quite easily, since all metals show an exaggerated effect, of somewhat the same order of magnitude, under sparking potential conditions.

Ionisation by Collision.

Having several times made mention of ionisation by collision, it seemed desirable to discuss it rather more fully at this stage. When ions are moving quickly through a rarefied gas, since their mass is considerable, their momentum also will be high, and, in fact, of such a magnitude that on colliding with other atoms in the space an electron or electrons will be knocked out of the outer ring of the atom.

The stripped or ionised atoms so formed will possess a positive charge, by virtue of having lost one or more units of negative charge, while the electrons which have been removed will attach themselves to other atoms in the rarified gas, and since they carry a negative charge, and the normal atom to which they have attached themselves was neutral, it follows that the net charge on the ions so formed will be negative. This, then, explains the formation of negative and positive ions by collision.

If the potential at which the tube or cell is working is below the sparking potential then ionisation by collision is due solely to collisions of negative ions with atoms or molecules of the gas, but as soon as the sparking potential is reached the positive ions also produced fresh ions by collision.

Some of my readers may be interested in the mathematical aspect of this fascinating subject, which I will endeavour to simplify as far as possible, though the subject is necessarily very complex and does not yield easily to simplified treatment.

Imagine two plates at a distance d apart, and let X be the value of the electric field between them, also let p be the pressure of the gas in millimetres of mercury. On illuminating the plate with ultra-violet light suppose that n_0 negative ions are liberated. Then imagine that each of these ions produces a fresh negative ions for every centimetre which it moves through the gas. It is obvious that this quantity a will depend on the pressure, temperature, and value of electric field. When X is small, a is almost zero, unless p is small.

If the number of ions produced in a distance x from the plate be n, then by considering them as travelling an infinitesimal distance dx, and integrating the result, we find that $n=n_0\varepsilon^{ax}$, which is the number of ions reaching the positive plate.

For different distances between the plates, if we chose these so that $d_2-d_1=d_3-d_2$, then we find that $n_2/n_1=n_3/n_2$.

Townsend's Results.

Townsend has shown, both mathematically and practically, that the value of a, i.e. the number of ions of one kind generated by one negative ion in travelling 1 cm. under the action of an electric field is $\frac{a}{p}=f\left(\frac{X}{p}\right)$

By further assuming one pair of velocity so considerably reduced that for all practical purposes it can be considered as starting from rest, then it can be proved that

$$\frac{a}{p}=N\varepsilon^{-\frac{NVp}{X}}$$

N is the maximum value of a/p, and is the number of collisions that an ion makes in travelling 1 cm. through a gas at a pressure of 1 mm., while V is the potential difference which is imagined as existing across the ends of the path in which an ion, starting from rest, acquires a velocity sufficient to produce other ions by collisions. The values of N, V, and NV can be found for different gases by ordinary experimental observations.

Since we have an equation giving n, we can find the photo-electric current from the formula $i=i_0\varepsilon^{ad}$, or from a far more complex formula involving NV.

Simplifying Results.

To simplify, it is necessary to miss out a great deal of more complicated working, and from this point to go straight on to a formula giving p_m, the pressure, and the maximum current value.

$$\frac{E}{p_m d}=NV=\text{constant}.$$

This result was given much earlier by Stoletow, who argued from different points, and the value which he obtained for the constant agrees well with the later value of NV found by Townsend.

The maximum value of the current

$$i_m=i_0\varepsilon^{X/V\varepsilon}.$$

Modifications of these formulæ by other workers lead to no simplification, and I do not propose to deal with them here. Experiments have been carried out, and curves drawn, to show the closeness of the theoretical

TABLE OF RESULTS.

Gas	NV	V	N	$1/N$	L	$1/N : L$
Air	340	27·1	12·6	0·0794	0·00745	10·65
Nitrogen	346	27·9	12·4	0·0807	0·00734	11·00
Hydrogen	153	27·8	5·5	0·182	0·01375	13·22
Oxygen	268	23·9	11·2	0·0893	0·00794	11·25
Carbon dioxide ..	380	23·5	16·2	0·0618	0·00512	12·07

ions to be formed when the collision occurs above a certain ionic velocity, and by realising that after each collision a negative ion has its

and experimental results, and absolute parallelism between the two has been demonstrated.

An interesting table of results

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might be given at this point, where NV is Stoletow's constant, V is the potential difference referred to above, N is the maximum value of a/p, then $1/N$ is the mean free path of an ion at 1 mm. pressure, and L is the mean free path of a gas molecule under the same conditions. The last column shows that on the average the ionic mean free path is about eleven times that of the molecule.

The treatment outlined above is not complete, for if the value of the field is sufficiently great then we must take into account the effects which are introduced by the motion of the positive ions. It has been shown that positive ions produce others by collision, even though the potential between the plates, though large, is still much less than that required to produce a spark.

Having now studied at some length the formation of ions by adhesion or by collision, we must now turn our attention to the effect of the surrounding medium on the number of electrons which are emitted from the photo-sensitive surface. There are a number of ways in which a modification of the surface may be brought about, and any such change in the surface may result in either increased or decreased activity or even may destroy the photo-sensitive surface. This may be a result of chemical action of the gas on the metal plate or surface; thus a mere trace of iodine or bromine vapour completely destroys the activity of a zinc plate.

Effect of Hydrogen.

One worker tried the effect of replacing the air surrounding a platinum plate which he was using with an atmosphere of hydrogen, and he found a great increase of activity resulted. This led to trying a platinum plate which had been polarised by hydrogen, i.e. the plate heated to white heat is allowed to cool in an atmosphere of hydrogen when a part of the hydrogen becomes adsorbed at the platinum surface.

The effect of various other gases was tried, and the order in which they affect the photo-sensitiveness was found to be—hydrogen, oxygen, chlorine, and ozone. Similarly, the effect of changing the material of the plate was tried, and it was found that the same order was given by plates of silver and zinc. This led to the conclusion that the discharging power, or sensitiveness, becomes greater as the electro-chemical potential difference between the plate and the surrounding medium becomes greater.

Pohl and Pringsheim, whom we have had occasion to mention several times before, found that the photo-electric effect was considerably decreased, up to a point, at any rate, by increasing the degree of evacuation, and this led to the formulation of the idea that the effect is to be supposed to be due entirely to interaction between the photo-electric

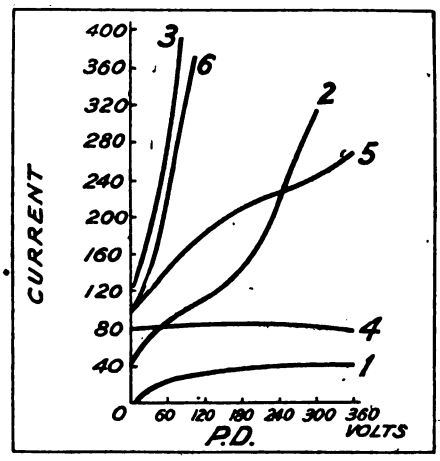

Fig. 4.
A selection of Varley's curves. For full explanation see text.

substance and the surrounding medium. Hallwachs and Wiedmann stated that "the presence of a gas is a necessary condition for the photo-electric emission from potassium. Other workers arrived at similar conclusions, and this led to the statement that thermionic emission, photo-electric emission and contact potential, all of which are, of course, related, were to be explained on grounds of chemical action.

Since the time of these statements, however, much work has been done on high vacua in connection with research on the Coolidge tube, thermionic valves, and the like. This all goes to show that an electric current can be maintained in the very highest vacuum obtainable, the electron acting as the carrier of the current.

It is very probable that the reason Hallwachs, and later Fredenhagen, were unable to obtain electric currents in high vacua was to be explained on the basis of "space charge," by which we mean the accumulation of electrons in the rarified gas or vacuum. Dushman, in America, repeated the experiments of Hallwachs and other workers, employing a still higher vacuum, and he found no difficulty in obtaining both thermionic and photo-electric currents under these conditions.

Dushman, in conjunction with Ives and Karrer, tried the effect of multiple distilling the potassium for their photo-electric cells, in an evacuated apparatus, which had been baked for a prolonged period at 350° C. No matter how gas-free the metal, or how perfect the vacuum, they found practically no change in the sensitiveness of the cell. Some results obtained by Millikan tend to show that the spectral sensitivity may be changed by such treatment, for he found that the presence of gas was necessary, for potassium at any rate, in order to obtain a response for the longer wavelengths. Removal of gas has no effect for wavelengths about 2,600 Å.

Photo-electric Fatigue.

Reference might be made at this point to a previous article dealing with photo-electric fatigue, which appeared in TELEVISION No. 8, p. 40, where the cause of fatigue was shown to be due to occluded gases. Piersol showed that for a number of metals there is an intrinsic photo-electric effect, which is independent of occluded gases, and by heating for a considerable time to drive these gases off, all abnormalities disappear, and a larger effect than before is obtained.

Welo, working in very high vacua with platinum, conceived the idea of illuminating the metal with two wavelengths of light to which the metal was very sensitive, so as to do away with any errors which might be introduced by using the total radiation. He finds that time is a very important factor in the removal of adsorbed gas layers. He, too, like Piersol, finds an intrinsic or primary photo-electric emission, which is constant, but was led to the conclusion that the adsorbed layer of gas filters out the electrons of low velocity.

The numerous facts which we have brought out during our study of this subject show the importance of a clear understanding of the influence of even a trace of gas on an effect of this kind, and it would not be surprising to find that many of the anomalies which have arisen from time to time in connection with claims for supersensitive cells and substances, which other workers have failed to verify, could be explained on similar grounds. In dealing with the Thalofide cell, it was shown that enclosing the cell in a vacuum increased its sensitiveness five times.

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Sydney A. Moseley

Writes from Berlin.

DEAR EDITOR,—The situation in London having developed so favourably, and the matter now being allowed to take its normal course, I write you these few lines from Berlin where television is in the best of health, hoping it leaves you the same at present.

However backward Germany has been in the matter of sound-transmission, there is every indication that she is fully alive to the great possibilities of television, and, so far as I can see here, she is going to make every endeavour to be among the pioneers in the latest development by sight.

The newcomer to Berlin is rather bewildered at first by the broadcasting organisations. There is, for instance, the *Funkstunde* and the *Rundfunk*, the first being a private company and the other really being an organisation similar to that of our own B.B.C. The presiding genius, or, as they call him, the *Rundfunkkommissar des Reichspostministers*, is Dr. Hans Bredow, who at the time I write is celebrating his twenty-five years' radio jubilee.

Dr Bredow is the late "Secretary of State for the Post Office"—a title he maintains still—and it was he who came over to London specially with his chief engineer, Dr. Reisser, to see what real television was all about. That in itself showed an enterprise which few other countries have exhibited. They also brought with them Dr. Banneitz, and the deputation of three evidently saw the great possibilities and immediately arranged with the Baird Company to instal a transmitter in the *Rundfunk* itself.

Agog with Excitement.

Naturally, on my visit to Berlin I went to see what was happening, and found the whole place agog with excitement. Indeed, the German engineers were so anxious for their country to be the first to put over a regular television transmission service that they could hardly withhold their patience. Before this article reaches print, however, we should have had the first of an interesting series of experimental broadcasts by wire and by radio, so that, after all, Germany may be the first country to put over regular experimental transmissions of television. It is a curious reflection that other countries less burdened with post-war problems, should have failed to show a similar initiative.

An interesting sidelight to the problem in Berlin is the appearance in the field of the Hungarian inventor Mihaly, who is striving hard to tackle the problem of television from different angles. Mihaly represents a different type from John Baird. He is inclined to be more self-assertive, and by this means has managed to impress the wireless world of Berlin of capacities which he does not altogether possess.

Now, Mihaly has been resident in Berlin for some ten years, and although still of Hungarian nationality, has quite naturally taken the fullest advantage which his knowledge of the locality has offered. Indeed, he was so able to impress the German broadcasting people that he obtained permission to experiment with his apparatus through a broadcasting station.

Nevertheless it should be emphasised that the attitude of the German wireless authorities is that they intend to find the *best system of television* and to adopt it whatever its origin actually is. I have been making special inquiries for the benefit of the readers of this magazine to ascertain exactly what it is that Mihaly has that Mr. Baird lacks, and my information at present may be summed up in one word—"Nothing!"

A Retrogressive Step.

He has been experimenting with cinema television which, in the opinion of wireless experts, is a step *backwards*. Unless my memory serves me falsely, I saw this method in transmission among the "has-beens" in the Long Acre laboratory some long time ago, and I have no doubt that as a point of interest Mr. Baird could furbish up his old machine again as, and when, he felt inclined to. Mihaly is clever enough, however, to surround himself even after all these years with an air of mystery. It is true, as one important

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commercial magnate said to me in Berlin, that one does not want to see a televised picture of a *picture*; but the Hungarian inventor whispers darkly that he has discovered "new things"; but since we have heard this story before I recommend readers to accept the rumours *cum grano salis*.

Technical Ingenuity.

That many technical points in the radio part of the Baird instrument that was sent out to Berlin were new to our German friends is very readily acknowledged by them. On the other hand, the German engineers have shown considerable ingenuity in other technical sides of radio-telegraphy.

Dr. Reisser, the chief engineer, entertained me at his laboratory in a little suburb just outside Berlin, and here I obtained some insight into the tremendous interest in research work that goes on in Germany. Besides seeing and hearing the latest in ordinary wireless, Dr. Reisser recorded and reproduced some of the London programme for me, and at the same time reproduced from a record two "still" pictures. Pending the regular transmission of television, the German Broadcasting Company has been putting over these still pictures, and as I write it is their intention to put them into the regular programme.

P.S.—As I dictate, an idea occurs to me how extremely useful television would be to the exiled, as I am myself at this moment. I should give anything for a look-in at some of the familiar faces at home; admitting the tremendous surprise to hear in Dr. Reisser's laboratory the golden voice of our announcers, what a greater thrill would it have been to have been able to look at him and to see the English face!

Late News.

And now, dear Editor, I give late news. President Kokow, who is chief technician of the German Post Office, conferred with me and Mr. Walter Schaffer at the laboratories just on the outskirts of Berlin.

And what immense laboratories they are! President Kokow had lots to say about television and expressed a great desire to meet John Baird. Incidentally, in the vast building there is a special research department for television. Germany certainly means to lead in the new science—preferably in co-operation with Great Britain.

Hoping to see you soon—through the televisor—

Yours for television,

S. A. MOSELEY.

THE PRESENT HOME OF THE BAIRD COMPANIES.

These premises, at 133, Long Acre, London, were taken possession of by the Baird Co., in January, 1929. They occupy the first and second floors, extending back as far as can be seen down the side street, and also the roof. From here the transmissions were made for the now famous transatlantic and "Berengaria" television tests in March and April of last year.

Those Short-wave Relays

According to a publicity release, issued by the General Electric Company, of Schenectady, N.Y., an English wireless experimenter has begged WGY (the G.E.C. broadcasting station at Schenectady) to come to his assistance. His integrity is questioned, and more important still, his reputation as an authority on wireless matters is at stake.

The amateur in question, who lives in Surrey, received WGY's short-wave stations so frequently and well that he told his friends about it. He was, naturally, extremely proud of his short-wave receiver.

Some of these friends, who had never before heard an American station direct, gathered at his home recently, and, true to his boasts, he tuned in 2XAF, one of WGY's short-wave stations. After listening to the music he broke in with the remark: "Listen, and you will now hear them announce seven o'clock over there and it's midnight here."

Unfortunately, what the assembled guests actually heard was Big Ben striking midnight! The radio host tried in vain to explain to his friends that they were really listening to 2XAF, but that the latter was re-broadcasting the British short-wave experimental station, 5SW. The quality of the re-broadcast was so good, however, that his friends refused to believe it, and accused him of perpetrating a hoax.

The amateur concerned then appealed to the manager of WGY, who obligingly testified that 2XAF really was re-broadcasting 5SW on that particular evening.

* * *

In connection with these re-broadcasts, which take place frequently, it is stated that the quality of the signal, as received from WGY in America, varies from excellent to poor, depending on whether atmospheric conditions are good or bad. Recently, the engineer-in-charge of WGY tuned-in that station at his home.

He listened intently and detected what he thought was a commutator ripple in the signal. Just as he was about to telephone the station staff about it he heard Big Ben striking midnight. The re-broadcast quality was so good that he was completely misled into believing that the programme to which he had been listening originated in WGY's studio.

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Light: The Essential of Television

Part IX.

By CYRIL SYLVESTER, A.M.I.E.E., A.M.I.Mech. E.

Light is one of the most important factors in connection with television, and one which must be carefully studied by all serious students of television. The principles and nature of light are by no means so widely known and understood as one would anticipate, and in this series of articles our contributor is elaborating them month by month.

IN the broadcasting of any scene or setting it should be remembered that the televisor, like an audience witnessing a play on a stage, will *see* the various objects from the front. The artificial light with which the setting is illuminated cannot possibly be projected upon the various objects directly from the front, although the footlights are intended to provide illumination of a more or less general character. It is from the front, however, that the *effect* is seen, from which it can be reasoned that

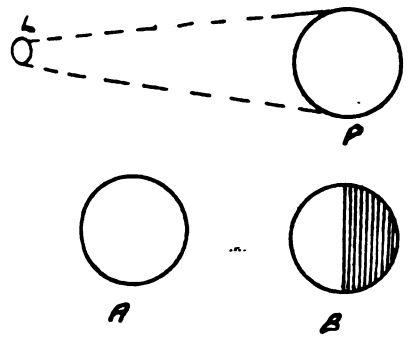

Fig. 1.

when an object is illuminated the appearance of the object depends upon the angle from which it is viewed.

This is illustrated in Fig. 1, which represents a sphere which is illuminated from a light source, *L*. We will assume that the light source is accommodated in a concentrating type reflector, and that the object is viewed from immediately behind the reflector. The sphere, if white, will appear to the observer as a white disc. There will be no effect of light and shade; that is, it will appear to be flat. If, however, the object is viewed from a position 90 degrees from the light source, as indicated at *P*, it will appear as a sphere with one side illuminated and the other side in darkness. The different effects are illustrated in Fig. 1, *A* and *B*.

Reflection Factor of Material.

The density of the shadow will be intense and its contour will be seen only by contrast between it and the reflection factor of the material to be seen from the front at the back of the object. If the back material is black, the shadow will be merged into this blackness; if the back material is fairly light, the shaded portion of the sphere will be seen very clearly. The back material, however, although it has a high reflection factor, and will reflect light upon the object, will not cause it to be seen from the front to any better advantage.

For the sphere to be seen in its three dimensions it is essential for the shadow to be decreased in density. The illumination, in intensity, must decrease gradually from the brightly illuminated sphere centre towards the extreme edge. This requirement can only be met by illuminating the object with another lighting unit located at the opposite side-front. This is illustrated in Fig. 2.

"Spill" Light.

Fig. 2 should be carefully considered, because it is one of the occasions where the "spill" light from a concentrating type reflector unit can, with advantage, be utilised.

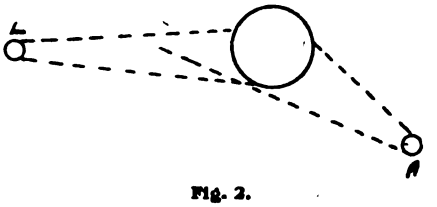

Fig. 2.

In this illustration; *A* is the additional unit. It is fixed in such a manner that the whole of the beam is not concentrated upon the whole of the object; the beam is cut by the object so that a large proportion is spilled over one side, and the actual spill light from the opposite side of the beam is just touching the side, as seen from the front at

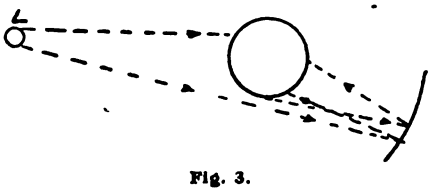

Fig. 3.

any angle. Figs. 1 and 2 should now be considered together.

Referring to Fig. 1, although looking at the object from the light source it appears flat, it may be said that a considerable difference in intensity exists. The point on

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the sphere nearest the light source, for instance, receives the direct rays. At points towards the edge the angle of incidence and reflection increases as the edge of the sphere is approached. The intensity, therefore, decreases.

The effect, therefore, of projecting light from *A*, Fig. 2, is to increase this intensity, so that the resultant effect is that the sphere is brightly illuminated on one side with a gradually decreasing intensity on the opposite side, which depends upon its illumination from the light source *A* alone. The intensity of *A* is considerably lower than the intensity of *L*; the required intensity, however, can readily be determined. Knowing the distance of the object from *L*, and the intensity of the latter, and the distance of the object from *A*, the calculations can be carried out as explained in a previous article.

If the sphere were located near the side of a setting it may not be at all necessary to install a definite lighting unit. Material of a high reflection factor may be used instead. This may be done as illustrated in Fig. 3. Here, again, *L* is a light source which is projecting

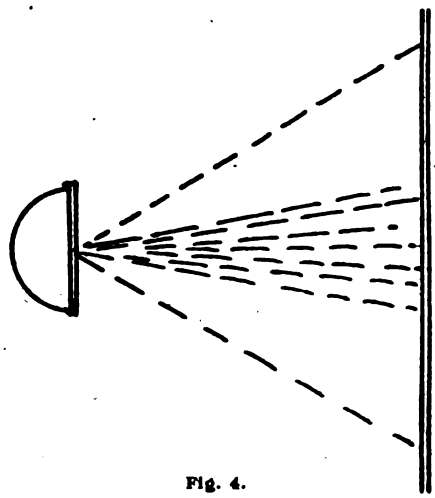

Fig. 4.

light, through the medium of a concentrating type reflector, upon a sphere.

Reflected Beam.

It is the front of the object (that seen from the front) that we are concerned with, so that the beam of light may cut the object as shown so that a portion of the light is spilled on to a screen located at the side out of the direct line of vision. The spilled light reaches the screen in the form of a beam, the angles of cut-off being the edge of the reflector and the edge of the sphere which is pointing towards the observer. The beam is slightly divergent, not so wide as the main beam. The reflected light from the screen can be controlled by forming the reflecting material into a concave type of reflector; the resultant beam of low intensity will effectively illuminate the shaded side of the sphere.

The advantage of this method of light control is that the intensity can be altered very easily. By altering the shape of the reflector the shape of the reflected beam can be made more or less intense as desired. The intensity can also be decreased by the adoption of a "box" type reflector in which cross reflections can be obtained, thus decreasing the intensity to the desired amount. It is, however, as I have pointed out, only practicable when objects are situated near the edge of a setting.

Multiple Lighting.

In the examples we have considered, the light sources have been in the horizontal plane. Although, in the illumination of a setting, many objects or parts of the setting would be illuminated in this way, it is impossible for some objects to be so illuminated. Objects at the side or in the centre of a setting can be illuminated by side lighting units; those, however, situated at the back (near a back-cloth) must be illuminated from the bottom or top. If the setting is an important one, that is if it is essential that it shall appear with its proper amount of light and shade, then special bottom or top lighting units are installed.

This means that the beams from them will be projected upon the object in much different manners than those we have just discussed. The units used are a type of flood-light projector. We will discuss their characteristics when light is projected upon a flat screen in the horizontal plane, and when the beam is angular to the plane. The latter is the condition which has to be met when light is to be projected upon a setting from bottom or top.

Flood Lighting.

In Fig. 4 is illustrated a sketch of a flood light projector projecting light upon a screen; the beam is horizontal. It will be seen that, as in the case of an ordinary lighting unit, the angle of divergence—the extent of the beam spread—consists of two beams of different intensities. In the case illustrated the angle of divergence is 60 degrees, and that of the centre beam (or main beam) is 20 degrees. In a unit equipped with a 1,000-watt lamp the difference in the intensity of the two beams can be clearly seen.

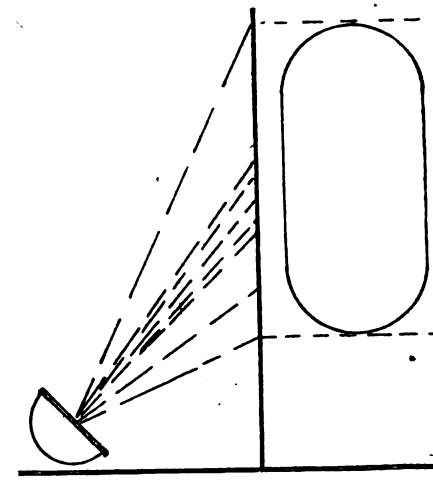

Fig. 5.

When such a projector is fitted at the bottom, to project light in an upward direction, the shape of the beam is altered as illustrated in Fig. 5. Here the beam is shown projected at an angle upon a screen; the shape of the beam is shown in projection from the screen. It will be noticed that the two beams (I have only shown one, but it must be assumed that the angle of divergence consists, as before, of two beams) have lost their concentric characteristics. We will discuss the difference in the beams.

Lighting from an Angle.

The bottom of the beam is nearer to the screen than the top. The intensity in the outside beam is therefore higher at the bottom than at the top. The beam is also now elliptical. This means that, whereas before we had to consider two beams of different intensities, we have now to consider two beams which vary in intensity from point to point. It may be said, in fact, that at no two points in the beam is the intensity the same. The shape of the beam, being irregular, also increases the difficulties which must be overcome if the setting is to be evenly illuminated.

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The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

Part VI.—COMMERCIAL DEVELOPMENT OF THE TELEPHONE

THE early days of telephony seem now to be bathed in a rosy mist of romantic achievement, but as a matter of fact they were mostly spent in a murkier mist in the law courts, a mist which, unfortunately, always envelopes the greatest advances of science.

But, fortunately for the writer, as well as for the reader, any attempt to pierce legal mists is quite outside the scope of these articles, so we may pass on, in a happier mood, to a short consideration of the development of the telephone from its early days of struggle to its present dominant position in the field of electrical communication.

The Telephone comes to England.

At the close of 1877, Bell's representative in this country offered a demonstration of the telephone to the Government, but the offer was not accepted. In the same year, however, a number of villages in Germany were connected together by telephone, and the late Queen Alexandra, then Princess of Wales, led the way in England by having her private apartments connected up by telephone to her children's nurseries.

In 1877 the first public exchange was opened in New York, and London followed suit in 1878, with Manchester and Liverpool a few months later. The telephone must indeed have been an assured commercial success in 1879, as it is on record that in that year no less a person than the great G. B. S. was employed as a canvasser by a telephone company in London! Glasgow was fitted in 1880, Paris and Berlin in 1881.

It may possibly surprise the younger generation to learn that the first great undertaking in this country to avail itself of the new invention was a railway, and it will certainly surprise the older generation to learn that the railway concerned was the London, Chatham and Dover.

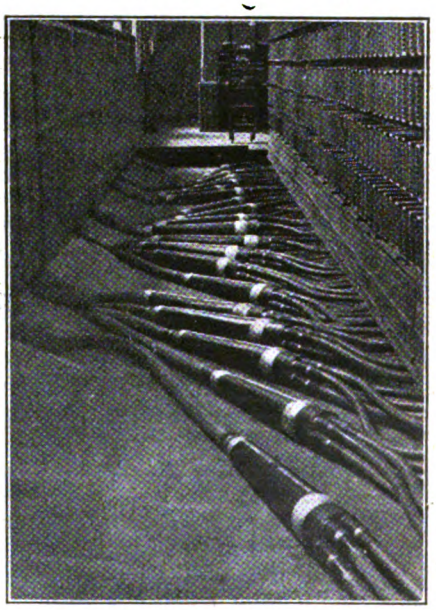
The first printed list of telephone subscribers was published in 1880, and some of those subscribers still figure in the current list. The only name of an exchange which persists from those early days is the Hop, which was originally situated in the London Hop Exchange. It is now an automatic exchange in Marshalsea Road and its troubles are not yet over, as a Cockney subscriber recently complained on the telephone that he didn't see how he could dial the first three letters of the exchange, in accordance with the instructions, as there were only two letters in OP!

Inauguration of Trunk System.

In 1880, when there were only about 30,000 telephones in America and 5,000 in Europe, our Trunk System was inaugurated by the opening of a line between Leeds and Bradford. Owing to the proximity of large towns in the North, the system developed much more rapidly there than in the South where London remained for another ten years in splendid isolation, with the exception of a single line to Brighton for the convenience, no doubt, of the same wealthy city class which lives there to-day.

The Post Office Steps in.

In 1892 the trunk system was taken over by the Post Office, and this purchase of the trunk lines by the Government foreshadowed the establishment of a State-owned telephone system. The service provided by private enterprise had proved far from satisfactory, and it was decided that the Post Office should take over the system when the National Telephone Company's licence expired in



Telephone Cables entering an Exchange.

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1911. The fact that the Government was going to take over the telephones did not, very naturally, imbue the company with any strong desire to spend much money on additional plant or maintenance, so that the Post Office had a stiff up-hill fight for some years after 1912, when the system was finally purchased.

To make matters worse, the needs of war depleted the country of plant and personnel, and the unreal trade boom which followed the war produced, unfortunately, a real demand for telephone facilities. Manufacturers could not cope with demands, the Post Office could not deliver the goods, and the Public wanted to kick something, so they kicked the Post Office, which was as good as kicking anything else. However, the trade boom collapsed, telephone equipment began to roll in, and it was even rumoured that someone had written to *The Times* to say his telephone had been installed without undue delay. Since then the kicks and delays have been better tuned to the same frequency.

The Automatic System.

The greatest technical advance made in line telephony since Bell first spoke to Watson has been accepted by the public as a matter of course, but the President of the Television Society who, as we have already seen, really does something now about such things, has described the automatic telephone as " the nearest approach of machinery to the human brain."

The telephone of each subscriber on an automatic exchange is provided with a dial, which he revolves by hand for calling-up purposes. The caller dials the first three letters of the automatic exchange which he wishes to call, followed by the four digits of the number required. If he has any trouble he dials " o " and is connected to a manual switchboard by which he can talk to, or at, the supervisor to his heart's content.

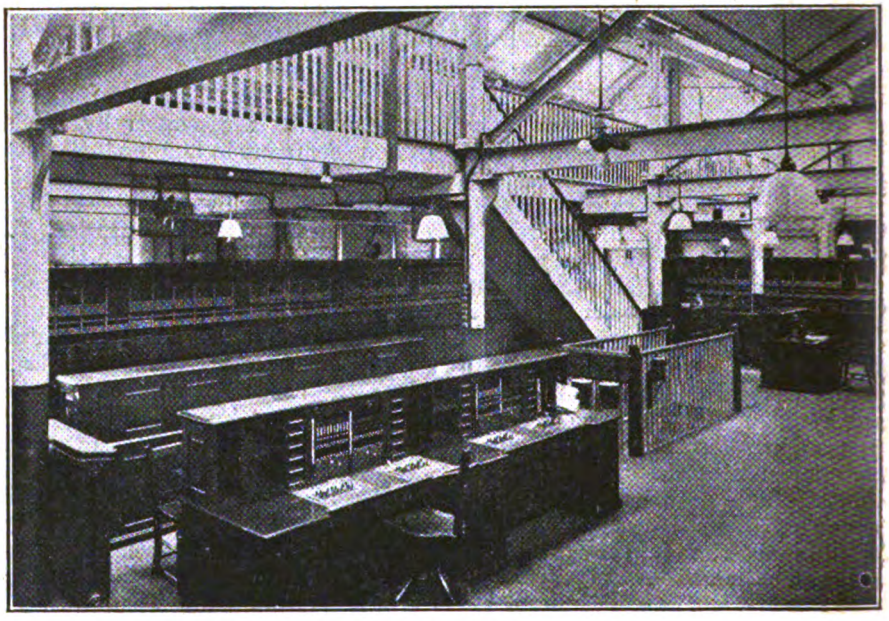
The first public automatic exchange opened by the Post Office was at Epsom in 1912, and forty-eight exchanges were in operation before the difficult problem of London was tackled. It was obviously a very different matter to develop a single automatic system to cover a densely populated area of over 300 square miles, but, after exhaustive investigation, it was decided to instal plant of the Strowger type, which had proved its worth in previous exchanges, along with the Director equipment, an arrangement specially adapted to meet the requirements of large cities. Indeed, the task which the Post Office undertook in introducing automatic telephony into London was immense, and the Department may well feel proud of its initial success, which augurs well for the future, though it will undoubtedly be a future of hard work, hard knocks, and no prizes.

The First Automatic Exchange.

The first automatic exchange in London was the Holborn Exchange, opened in November 1927. Six more were added by the end of 1928, when the amount of automatic traffic being dealt with in London was well over a million calls a week. The policy is to instal automatics when new exchanges are required due to expansion or replacement, and the complete conversion of London to automatic working will take, on these lines, about twenty years. Meanwhile, intercommunication between manual and automatic exchanges has been arranged for by the installation of most ingenious apparatus at the manual exchanges. It is satisfactory to find that the percentage of automatic calls established on the first attempt is already nearly as high as for manual exchanges, and that between subscribers on automatic exchanges, when the dialling is carried out correctly, the percentage of wrong numbers is less than 1 per cent., whereas with manual working the percentage is 3·6.

The Human Element.

The human element must always be present to a greater or less extent, and it is remarkable how a visit to a busy exchange invariably alters the opinion of a hostile subscriber, especially regarding the efficiency of the operators. The Post Office takes the greatest pains not only in training girl operators, but in selecting the most suitable candidates. In London, only 20 per cent. of those interviewed are considered suitable, which is not much to the credit of the elementary school system as the large majority of those rejected are deemed unsuitable on account of bad spelling, bad writing, or bad speaking.



A Telephone Switch Room.

At the subscriber's end the human element must always be present, and in London this human element has led to many mistakes at the opening of automatic exchanges, especially that of abandoning calls prematurely, and, to a less extent, wrong dialling, but these are only growing pains, and, as experience has already shown, are of comparatively short duration.

Amusing Difficulties.

The Post Office has arranged that each subscriber should receive a

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personal explanation of the use of the dial at his own premises, and every subscriber is invited to visit a working model automatic exchange installed in suitable premises near the real exchange. Amusing difficulties are constantly cropping up, like that of the Hop Exchange already mentioned. For instance, a Hebrew gentleman was recently much annoyed when he failed to get on to the Wimbledon Exchange by dialling the letters V I M.

International Telephony.

Telephony in Europe is naturally far more difficult and complicated than in America, owing to different languages and multiplicity of control, though from the purely technical point of view long distance services over land have presented no difficulties since the introduction of telephone repeaters and the thermionic valve. In America, by 1884, it was possible to telephone between New York and Boston, 230 miles; by 1892, between New York and Chicago, 900 miles; and by 1915, between New York and San Francisco, 3,400 miles, with the help of the thermionic valve. London to Bagdad is about the same distance as New York to San Francisco, but there is no service approaching such a distance on this side of the Atlantic.

In 1891 England was connected to Paris, in 1903 to Belgium, in 1914 to Switzerland, and in 1922 to Holland, but a great step forward was made in 1923, when a standing committee, called "The International Consultative Committee," was formed with the object of developing international telephony in Europe. This committee has no executive power, but it has already obtained a large measure of agreement on fundamental issues, and has awakened an international interest in telephony.

It is now possible to communicate by line telephony between this country and France, Germany, Spain, Portugal, North Italy, Switzerland, Austria, Hungary, Czecho-Slovakia, Belgium, Holland, Denmark, Norway, and Sweden. There is no doubt that the lack of long distance services in Europe was due mainly to the absence of any organisation to advance them, and we are justified in holding high hopes for the future from the rapid advance which has been made since the Consultative Committee got to work.

The World's Telephones.

Throughout the world at the present time there are about 33 million telephones in service, and, of these, 20 million are in North America. The number of telephones per 100 inhabitants is about 16 in the U.S.A., 13 in Canada, 10 in New Zealand, 9 in Denmark, 8 in Sweden, 7 in Australia, 6 in Norway and Switzerland, 4 in Great Britain and Germany, 3 in the Netherlands and Finland, and 2 in France, Austria, Belgium and Argentina.

The Information Desk at a Telephone Exchange.

The rate of increase of telephones in Europe is greater than in North America, the 1927 figures compared with the 1926 figures showing an increase of 6·4 per cent. in Europe and 4 per cent. in North America.

In six of the great cities of the United States the number of inhabitants per telephone is as low as 4, whereas in London, Paris, and Berlin the number in each case is between 9 and 10.

Britain's Telephones.

It is not easy to understand why in the United States there should be for a given number of persons four to five times as many telephones as in Great Britain, but the same might be said of motor cars, in which case the difference is still greater, in fact, about twice as great. There are, of course, differences in temperaments and habits, and in the United States, owing to the higher wage level, the cost of a telephone, though rather higher than it is here, bears a much smaller ratio to the wage earner's income. It looks, indeed, as if we can never hope to reach the American standard of development unless there comes a radical rise in our wage levels.

When the Post Office took over the system in this country in 1912 there were 700,000 telephones. Ten years later there were 1,000,000, though the war years had intervened and now there are about 1,750,000.

During the last four years the Post Office has expended forty-four million pounds of capital in the development of the telephone service, and five-sixths of the telephone wires are now laid underground. Taking the last five years, this country shows a higher percentage of development than any of the chief telephone-using countries, e.g., 56 per cent. increase in England compared with 36 per cent. in Germany, 33 per cent. in Canada, and 29 per cent. in the United States.

Telephone Progress.

Every day we have more than three million conversations by telephone, and though we are still a long way from saturation point, even under present conditions, we are now justified in classifying the telephone progress throughout the country as satisfactory, and in confidently anticipating that before long it will rise from satisfactory to good.

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War and Television

By W. F. F. SHEARCROFT

At a recent demonstration of television broadcast, a soldier watched the pictures, wide-eyed and thoughtful. Beneath his breath he muttered, "In time of war!" and it was easy to read his thoughts. The soldier, however, is a simple soul, like unto the novelist. He sees the obvious—hence we get the crop of war stories in which television plays a part.

There is more than the obvious, however, in this point of view. There is a subtle significance which overshadows every other aspect of television. The vast majority of our population live within the memory of the horrors of war. We may still thrill at the telling of exploits of bravery. We may still be proud of the noble sacrifices which we made as a nation. We may still glory in the achievement of victory. At times we may recall that wave of patriotism which swept our country, and know, in our inner hearts, that we should respond to the call again.

Yet there are other memories. We still shudder as we think of those dry-eyed women who smiled as the train left Victoria Station, smiled fixedly while there was a chance that the loved one might look back. Smiled, while their hearts stood still or broke. We still shudder at the maimed wrecks that crawled back to Blighty. Deeper still in our hearts we pray that never again may the terrors of war be loosed among us.

We look around at international relationships and see in the strain, with rumour rampant, that intense longing and striving for peace. We may mock at the League of Nations, yet it is a world-gesture. No sane, thinking man wants war, with all its crude psychology of the animal that lurks beneath the veneer of civilisation.

Yet there are sane, thinking men, kind-hearted men, men striving might and main for peace, who believe that war will overwhelm us again. They are not all fanatics, they are not all makers of munitions or sordid profiteers who want war for what they can get out of it. Neither are they all hot-headed youths, with energy to burn, who see a great adventure in war. There is a real danger, a danger that no political forethought can circumvent. No alliances of this nation with that, no scheme of disarmament will ever remove the danger entirely.

War can only be finally abolished by making it impossible, and I suggest that television is well on the way towards accomplishing such a happy result. Nations do not go to war knowing that they are doomed to defeat. With such knowledge they would negotiate and bide their time. No commander would launch an attack knowing that the enemy knew his every move. Even the forlorn hope is a *hope*.

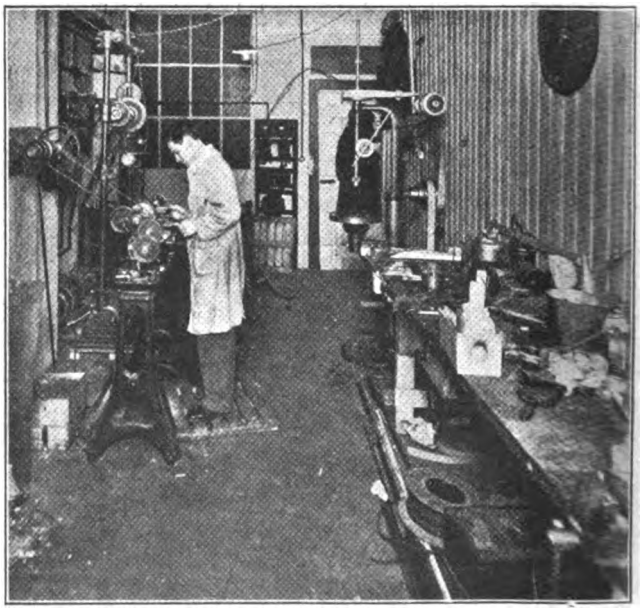
Do not the wonders of television mean just all this? Noctovision has demonstrated that we can see in the dark, television that we can bring distance near to us. The future will see to it that there is no secret planning, no surprise attacks. Day and night we shall be able to watch the movements of an enemy—go to sleep possibly, and let his movements wake us up by the ringing of a bell. The mere idea of war is reduced to an absurdity.

Let us be critical and call our present state of progress in television crude in the extreme. Frankly let us realise that to-day such things as the watching of an enemy in this way are impossibilities, but—think back.

From a hundred miles away the opera at Covent Garden has just come to me across space. Not being a musical expert, the delusion to me is perfect. I can shut my eyes, and I am in my seat with the stage just in front of me. Orchestra and singers are as real as they would be were I actually present with them. Yet it seems but a few days ago that I fetched my neighbour from his cosy fire, and we sat for an hour with phones glued over our ears, because I had heard a strange grunt through my earliest wireless set. We were not rewarded with another grunt, but I remember the first one was a notable achievement.

I always remember also how the proud possessor of a mass of wires and apparatus, which looked like a cross between a railway accident and a Heath Robinson cartoon, thrilled a country audience with a series of howls and groans which would have done justice to the slaughter-house of a pig farm. During a temporary lull, filled with whistles and squeaks, he smiled at us and said, "That was the Prince," and we clapped like mad. That was only nine years ago.

Give television nine years—it is already streets beyond those howls and grunts—and see if you can deny the possibility of the all-seeing eye—and no more war.



A corner of the Machine Shop in the Baird Laboratories, where experimental television apparatus is built.

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The Television Society

Report of the May Meeting

THE concluding meeting of the Television Society for the present session was held at the Engineers' Club, Coventry Street, London, W.1., on Tuesday, May 7th.

As at the previous meeting of the Society the evening was opened by an informal discussion at 7 o'clock for members only. On this occasion the subject was a paper printed in the May issue of the TELEVISION MAGAZINE—"A Quantitative Analysis of Television."

The discussion was opened by Mr. Owen Harries, the author of the paper, who emphasised some of the points made in his original article, and gave his reasons for setting forth his formulæ in that way.

Mr. R. R. Poole and Mr. J. C. Wilson took part in the discussion, and criticised some of the aspects of Mr. Harries' proposed methods of analysing and comparing different television systems.

This section of the meeting was very well attended, but the great attraction of the evening was the formal meeting, and at this there was an exceedingly large attendance. The chief item was a paper by Capt. R. Wilson and Mr. A. A. Waters on "Some Practical Considerations in the Building of Television Apparatus." To illustrate their paper these gentlemen had brought both the transmitter and receiver which they had jointly built, and showed them in action.

In addition to this, Mr. R. R. Poole, B.Sc., had brought a model to demonstrate mechanical exploring, as the speed of the disc increased from zero, and with this also he demonstrated synchronising errors and band slip.

Talking Films.

Mr. H. S. Ryland, F.O.S., brought a model of a talking film projector, and opened the formal section of the meeting. He had chosen "Talking Pictures" as his subject, he said, first, because he was doing a certain amount of work on them, and secondly, because its problems bore some relation to those involved in television. In sound one was content with a frequency of 5,000 per second and hoped to be able to use 10,000, while in television a frequency which appeared to vary considerably with different writers seemed to be needed.

Fig. 1.
A sample of the type of film on which both visual and sound records are photographed. The film is standard width, the sound record being confined to a narrow strip at the side. It takes the form of fine horizontal dark lines of varying density.

"'Talking Films,' so called, may be divided into three classes," continued Mr. Ryland.

"(*a*) The normal picture film operated in conjunction with a gramophone record run in synchronism with it.

"(*b*) A 'sound' film proper, in which the sound record (Fig. 1) takes the form of a narrow band on one side of the film, the density of which varies with the sound wave form.

"(*c*) As (*b*), except that the 'sound' record varies in width in accordance with the sound wave form.

"In some cases the sound record in type (*c*) is made on a separate film (Fig. 2). The sound record then occupies the whole width of the film.

"Type (*a*) I do not propose to discuss.

"Type (*b*) is interesting, and with care good results are obtainable. The disadvantages of this type are, first, the difficulty of developing the film so that the density varies strictly with the wave form, and, second, that small scratches and marks on the film become comparable with the actual density changes of the record, thus producing noticeable stray noises.

Separate Sound Film Best

"Type (*c*) is better than type (*b*) in that the development difficulty is eliminated. In my opinion the modified type (*c*) film is by far the best. Development troubles are eliminated; the actual record is larger, so that reproduction is simplified; marks and scratches on the film are relatively unimportant, and when desirable the picture film alone can be used.

"The method of recording films of type (*b*) is briefly as follows: The speech currents from the microphone are passed to a suitable amplifier. In the plate circuit of the last valve

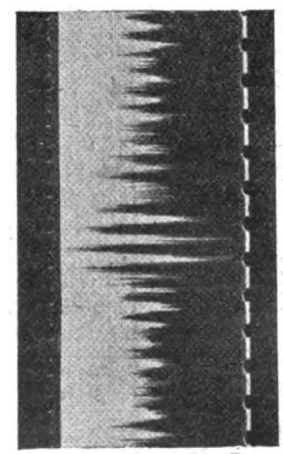

Fig. 2.
An alternative form of sound record which is photographed on a separate film. The impression of the sound waves can be seen more clearly. Mr. Ryland, in his address to the Television Society, stated that the separate sound film is preferable.

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is connected a neon tube. The light from the tube varies with the amplified speech current. The film is passed before a narrow slit (generally .0005in.) which is illuminated by the neon tube. Another method is to focus the light from the neon tube on to a narrow slit and form an optical image of the slit on the moving film.

"To make records of type (*c*) (or modified type *c*) the amplified speech current is passed to an oscillograph of special type. When the steady plate current alone is passing, the oscillograph is arranged to project a narrow line (.0005in. generally) image, extending over one-half the record space on the film; as the film passes one-half its width is thus exposed.

"When the fluctuating speech currents pass, however, the line image moves back and forth across the film, thus exposing the film, as it passes, in a wave form.

"For reproducing purposes a narrow line of light is focussed on the film (generally .0005in), or the film moves in close proximity to an illuminated slit. The amount of light passing through the film is controlled by the sound record (whether type *b* or type *c*), it then illuminates a light sensitive cell. The current from the cell is amplified, and operates the loud speakers."

"Talkie" Faults.

This description, said Mr. Ryland, was necessarily brief, but on a future occasion he hoped to be able to deal with the subject more fully and demonstrate the sound film.

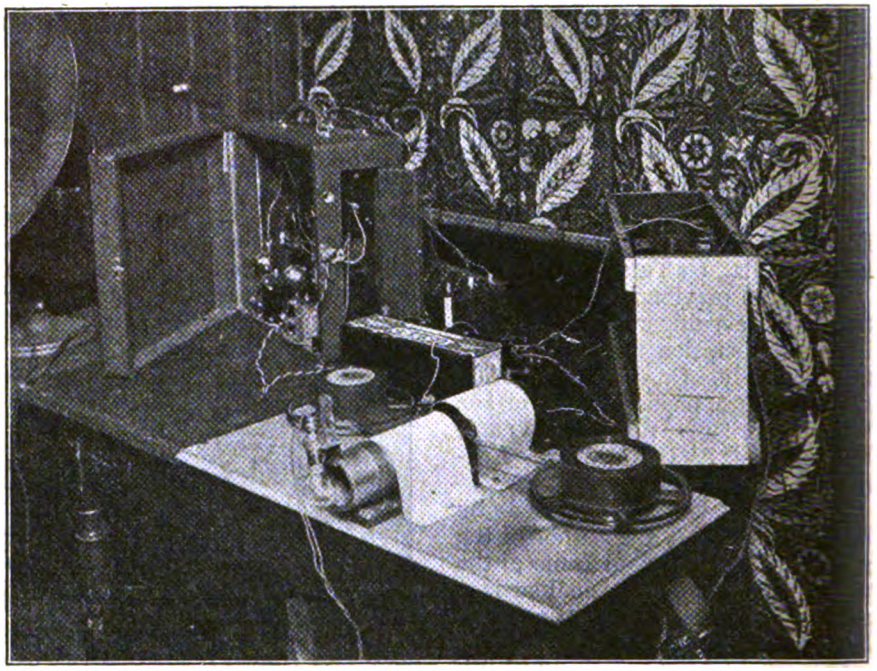
"I have seen these talking films," continued Mr. Ryland, "at various cinemas, and to me they are very poor substitutes for the real thing. I cannot raise any enthusiasm for a chalk and charcoal picture of unnatural size, with sounds more or less synchronised with and out of proportion to the size of the image on the screen.

"Again, when I see a 'close-up' showing somewhat unpleasant tongue movements of a singer, with the voice out of proportion, I am amused rather than moved by the sentimental character of the song. However, I look forward to the time, possibly not far distant, when we shall have moving pictures in colour, arranged to give a semblance of stereoscopic relief, and shown approximately *natural size on the screen*, and with voices or sounds appearing to originate from their proper places on the screen.

"In many cases they will still be a substitute for the 'real thing'; in other cases, places will be seen on the screen which cannot be shown on the legitimate stage."

* * *

Dr. Tierney said it was very interesting to hear Mr. Ryland's practical definition of the difficulties that attended the production of sound films. At present we seemed to be living a little in advance of our time with regard to the application of ascertained laws, but notwithstanding that there was the satisfaction of knowing that the solving of those problems was nearing completion, and he anticipated that before long we should be able to listen to a reproduction giving a reasonable amount of fidelity as to the origin of the sound produced.



Mr. Ryland's talking film exhibit.

Summer Outings.

It would interest members to know that a visit was contemplated to a sound film works, and he hoped that those who had made application for tickets would be fortunate enough to secure them, as he understood the number in any one party was strictly limited.

Those fortunate enough to visit the works would be able to follow up Mr. Ryland's remarks with some practical observations as to how films were produced, and he was sure they would look forward to the fulfilment of Mr. Ryland's promise for the autumn session. As Mr. Ryland had to hurry away he took that opportunity of thanking him on their behalf for his very interesting address.

Sometimes reproaches in the form of letters had been sent to TELEVISION on the lack of constructive articles in the journal. He could not help thinking that those who wrote showed a lack of judgment, for if one thing was certain it was that the meetings of the Society had been essentially practical as far as had been possible under the restrictions at present imposed.

As he had already pointed out, it would be idle to give out the latest and most advanced details in the form of constructive articles because, in the absence of any broadcasting service, the sets so constructed would be of no practical use. Notwithstanding the fact that that difficulty was now shortly to be overcome, there still remained the patent situation, which he was glad to say was now nearing an equitable solution, and it would not be long before some constructive articles would be forthcoming.

At the same time, they had the satisfaction of knowing that at least one of their members had derived considerable pleasure and profit in constructing the set described in one of the earlier numbers of the journal. Captain Wilson and Mr. Waters had

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come forward to tell them something of their experiences in constructing their apparatus. He had much pleasure in calling on Captain Wilson to read his paper.

* * *

Shadowgraph Experiments.

"Before any attempt was made to construct any form of shadow vision apparatus," said Captain Wilson, dealing with "Some Practical Considerations in the Building of Television Apparatus," "it was realised that it would be highly advisable to study the fundamental principles, and with this object in view every particle of practical information was collected from English and foreign periodicals, and from any other source where possible. After studying for a certain period (which was longer than had been anticipated) the general principles, it was decided to construct simple apparatus following the lines described in previous issues of TELEVISION, to alter the lay-out and try to improve on this by incorporating some of our own ideas.

"The apparatus naturally falls under three main headings: (i) The Transmitter, (ii) the Amplifier, (iii) the Receiver. I only intend to give you a brief outline of the apparatus. I leave Mr. Waters, who has had a great deal of experience in constructional work, to deal with that portion of it in his own way.

"We had three main aims in constructing this apparatus: (1) convenience and portability of the transmitter and receiver; (2) an amplifier to function efficiently on mains voltage, saving the expense of a convertor or numerous H.T. batteries; (3) a means of keeping the image fairly steady without going to the expense of synchronous motors or other means.

"With regard to (1), this portion was made with the idea of being very compact, and so that it could be moved about when necessary without having continually to uncouple wires, etc. Therefore plugs and jacks were used, the main input leads were kept as short as possible, and the cell lead was lead-covered to prevent any capacity reaction. This was considered a very important point."

Apparatus Used.

Light Source.—"Various light sources were tried, including carbon arca and Tungsten arc lamps. The former gave the best illumination, but proved too unstable, for with every flicker of the arc, the image became very faint. The Osram metal filament lamp was found to be the best in the end, and was finally used."

Lenses.—"Various systems of lenses were tried for the optical portion, but it was found that an ordinary convex single projection lens gave the best focus of the object on the wall."

Discs.—"Many different combinations of spirals, diameters, and sizes of holes were tried, but the 30-hole single spiral, with about $\frac{1}{10}$ in. square holes was found to let through sufficient light, and at the same time to give the best detail."

Selenium Cells.—"Various ratios from 130–1, using 200 volts potential, to 30–1, using 60 volts, were experimented with. The latter gave the best results, the higher ration cells giving rather splodgy effects, probably due (it was thought) to the holes being too large."

Photo Electric Cell.—"We have decided to give the demonstration to-night using a photo-electric cell, as during the last few days one of our selenium cells has refused to function, and the other one has become rather patchy in results.

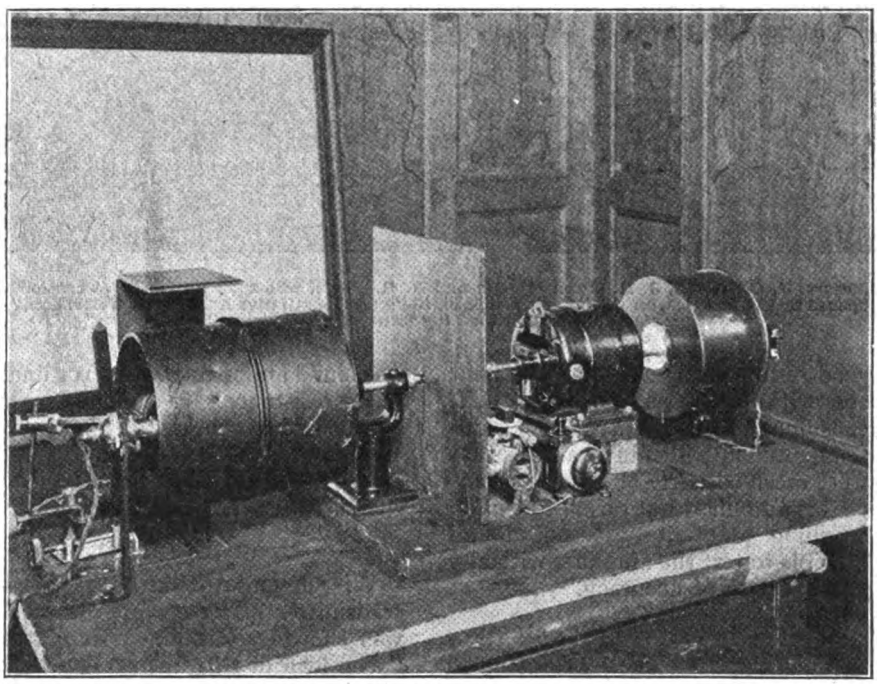
"It was found necessary, before any results could be obtained with this cell, to put it in a metal box properly insulated and complete with a single stage of resistance coupled amplification. After this preliminary stage the output is passed on in the ordinary way to a push-pull amplifier. The voltage of the cell does not appear to be at all critical when using direct lighting. The advantage of a photo-cell over a selenium cell for sending shadowgraphs would appear to be the fact that the transmitter and receiver can be run faster (there being no lag), and therefore an image with more detail results. The same voltage as is applied to the amplifier is used to feed the cell."

Amplification Problems.

(ii) *The Amplifier.*—"Transformer coupling was first tried, but it was found that too high a voltage was required; it gave certain results on occasion, but it proved to be too unstable.

"Resistance coupled amplification was next tried, and worked satisfactorily, but a voltage of 400 was found to be necessary. Therefore it was discarded, and the push-pull system tried. This was first hooked up, and after a fairly long period worked satisfactorily, using 220 volts. It was, however, found necessary to strike the neon lamp with a separate voltage before the A.C. impulses were imposed upon it, and to insert chokes and condensers in the amplifier to prevent any feed back.

"The next step was to put the whole lay-out on a board and get rid of all loose wires. When this was done the amplifier refused to function, and



The Drum Scanning exhibit shown by Capt. Wilson and Mr. Waters.

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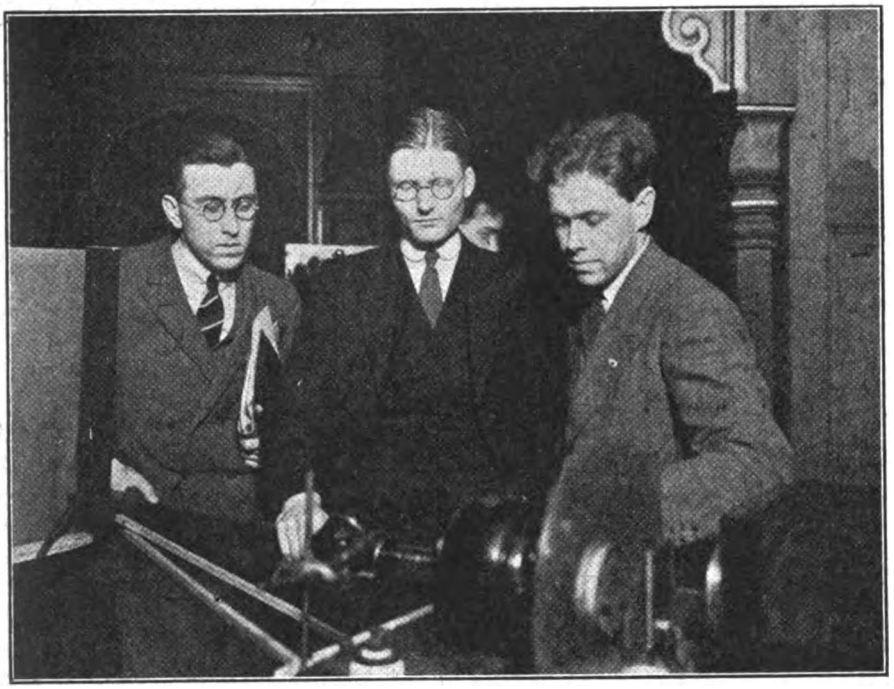
oscillated violently (laughter). The lay-out was changed, valves and grid bias values altered, and then it functioned satisfactorily, but with one great disadvantage, it consumed between 80 and 100 milliamps, and it was found that no values would stand this load for very long.

"This problem was actually solved by Mr. Waters. He made further alterations and modifications, introduced condensers in the circuit, and finally this amplifier was made to give good results, using a voltage of about 200 with about 30 milliamps H.T. consumption. Certain of the Baird Company experimental transmissions were received fairly clearly by means of this amplifier, but owing to lack of scanning data it was not found possible to test the amplifier with any great degree of accuracy."



Messrs. J. C. Wilson, J. H. Owen Harries and R. R. Poole, who took part in a discussion, opened by Mr. Harries, on the latter's article entitled "A Quantitative Analysis of Television," which appeared in the May issue of "Television."

Synchronising Arrangements.

(iii) *Receiver.*—"This was designed to be a compact, separate unit. A scanning disc exactly the same as that at the transmitter is mounted on a 200 volt. D.C., G.E.C. motor. Apart from the 1000 ohm series resistance controlling the motor, a magnetic brake is used in order to keep the image steady. Various electro-magnets and different sized studs were tried on the receiving disc, but what gave the desired result was a single horse-shoe magnet through the jaws of which run the disc.

"On the periphery of the disc are placed four rivets, on opposite sides and adjacent to each other. Current at 4 volts is used to energise this magnet, and when a revolution-indicator was connected up, it was found possible to control the speed of the disc within a margin of 10–15 revolutions per minute, and with a little practice the image could be kept almost continuously steady. This was found impossible with an ordinary series resistance. If elaborated, this effect could be considerably improved. This device was moreover found to be extremely simple, effective and cheap."

Drum Scanning.

With regard to the novel "drum transmitter and receiver" which he was showing, Captain Wilson said: "The idea of this was evolved when viewing the scanning of an ordinary 30-hole single spiral disc by the spot light method. At the focus of the lens system, viewed through a ground glass screen, the formation of the scanning pattern appeared to be rather lopsided, especially on the outer circumference of the disc. It was therefore thought that if a drum could be utilised instead of a disc, possibly a better and truer scanning effect might be obtained. It was realised at the same time that this lopsided effect might be due to the scanning disc not being accurately cut, and to the fact of it being too small. However, it was decided to construct a transmitter and receiver on the same shaft, thus avoiding the trouble of synchronising, so that experiments could be carried out.

"The first problem was how to make the drums cheaply, and to run smoothly. These were first made out of sheet aluminium, but they were found to whip too much at any speed. Finally aluminium saucepans were suggested, and these were found suitable when the bottoms had been cut out and replaced by fairly heavy gauge aluminium.

"A condenser and a 100-watt Pointerlite lamp are mounted inside the transmitting portion, and an adjustable diaphragm is placed in front of this drum, in order that one spot at a time only shall be seen on the screen. The lens system has not yet been properly worked out. Any criticism as to the merits or demerits of this system would be very welcome."

Results.—"As regards the results obtained, these are best judged by the visual demonstration, which we propose to attempt to give."

* * *

Constructional Problems.

Mr. Waters opened his brief description of the constructional work carried out by saying that although he could not offer members much help on electrical problems, he would be only too pleased to give members faced with mechanical difficulties any advice or assistance possible in that direction.

In their first transmitter and receiver, Captain Wilson and himself used a disc with a double spiral of 24 holes, and an interruptor disc. Both discs were driven by small 6-volt motors, and it might interest them to know that the interruptor disc was still in use.

Their first trouble was with the motors, which ran very well for about 24 hours, and then the brushes began to wear. Just as things were beginning to happen, the motors got hot and slowed down. They were consigned to the junk heap.

Two better motors, G.E.C. 1/40th h.p. 220-volt Universal Motors, were tried and found to work very successfully indeed.

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The next step was to obtain a neon lamp. The ordinary "beehive" type was used in their first experiments and produced quite good results. A letter H lamp was quite a good substitute. If a piece of ground glass was placed between the lamp and the disc, one did not see the latter.

The most difficult part of the apparatus to design was the amplifier. It was, too, the most important part if one desired really good results.

The first amplifier tried was transformer-coupled and did not prove satisfactory. Next a 3-stage resistance-capacity coupled amplifier was tried out and certainly gave better results, but required a high tension voltage of at least 350 to 400 volts. As so high a voltage entailed either a Generator or A.C. Mains Supply, and as the cost of either of them would have been much more than the experiment warranted, the push-pull method was tried. This they were now using; but he did not think a push-pull amplifier was entirely suitable for television work, owing to the lag which occurred in any transformer-coupled circuit.

It was, however, quite a good way of getting maximum amplification with a minimum voltage, though troubles had frequently occurred in the particular instrument used. Recently it became unstable, and refused all coaxing; the trouble proved to be due to a faulty condenser.

Lighting and Lenses.

The next question was that of light. Naturally, one first of all tried a 100-watt gas-filled bulb, and it was quite O.K. if one had a good selenium cell. Not having a very good cell, a 500-watt bulb with an ordinary reflector was used, and their first shadowgraph resulted—it was of one arm of an "X." As their main object was to get something to improve upon, they started to better the light, first, by excluding as much outside light as possible, and, second, by getting a parallel beam of about 2½in. diameter. Professor Cheshire's articles on "Optics," published in TELEVISION, were very helpful in arriving at the sizes of lenses required.

Suitable lenses could be obtained from a number of firms. Griffin & Co. supplied the particular lenses used in their experiments.

After getting fairly satisfactory results with one disc it was decided to build a separate receiver. That, of course, introduced the problem of synchronisation. After much thought he was of opinion that two A.C. induction motors would be much the simplest way to carry out the experiments, but having 220 volt. D.C. Mains they decided to see what could be done with direct current and thus keep down expense.

The system of speed control devised was both effective and inexpensive, but it was important that a very smooth resistance should be used. It should have a value of about 1000 ohms and be capable of carrying half an ampere. The slider type made by Zenith or Isenthal was excellent. Unless a lathe and plenty of time were available it was not advisable to try to make a resistance. The scanning disc one could make quite easily.

Here Mr. Waters interrupted his lecture to demonstrate the cutting of a scanning disc from a sheet of 21 S.W.G. aluminium. For this purpose a pair of converted trammels were used, a cutting tool taking the place of one of the legs.

Cutting and Mounting Discs.

A small hole was drilled at the centre of the disc to act as an anchorage for one leg of the trammel, which was then, a section at a time, moved over the whole circle, the tool in the other leg scoring a shallow channel in the aluminium.

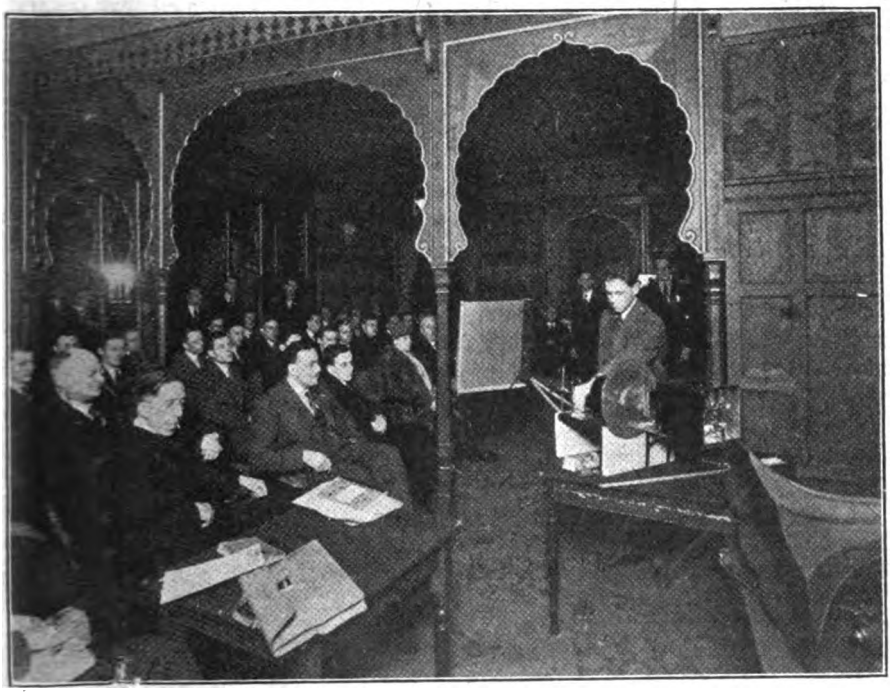
When the disc was about half cut through on the one side the sheet was reversed and the other side cut out. This method gave a perfectly circular disc with a minimum of trouble and in a very short time. During the process it was advisable to lubricate the cutter with oil.

Squaring a Round Hole.

Continuing his address, Mr. Waters said that before cutting the disc it should be carefully marked out, and one needed a pair of 6in. dividers for the job. After drilling the size of hole required the next step was to square it. That could be accomplished with a drift or square file. The size of the holes in their discs was $\frac{1}{10}$th in.; if a smaller size was wanted the tang of a small file could be pushed into the holes, and would give a square good enough for experimental purposes. Drifts could be bought quite cheaply from a good tool stockist or jeweller's sundriesman, or they could be made from silver steel.

A home-made drift, used for the present disc, was passed round for inspection.

The next step was to mount the discs, and it had been suggested that "Meccano" parts are good enough for mounting; but discs should run very true, otherwise results were not satisfactory. Of course, a lathe was



A General View of the Meeting. Mr. Ryland is on the left, seated immediately behind the table.

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necessary for making the mounting which they were using. The disc was fitted on a register and held by 4 2-BA screws, this being done to enable any discs which it was desired to try out to be readily fitted. If any member wished to know the dimensions of the mounting he would be pleased to supply the information.

The Phasing Device.

The apparatus incorporated a phasing device, though it was not required for the present experiments. Phasing could be carried out by rotating the motor on its axis; in their receiver this was done by means of a worm drive, the case of the motor being mounted in two plain bearings. That construction was not a job to be done without machine tools, although he had no doubt the ingenuity of those whose equipment did not include a lathe and similar machinery would prove equal to solving any difficulties which might arise should they undertake the construction of a phasing device of that sort.

One method of overcoming the difficulty was to mount the motor case in plain bearings and attach a small arm to it. When a slight adjustment of phasing was necessary, one merely had to reach round to the back of the case and rotate the motor case by means of the lever until the required position was secured.

With a few wood-working tools the wood framework could easily be made.

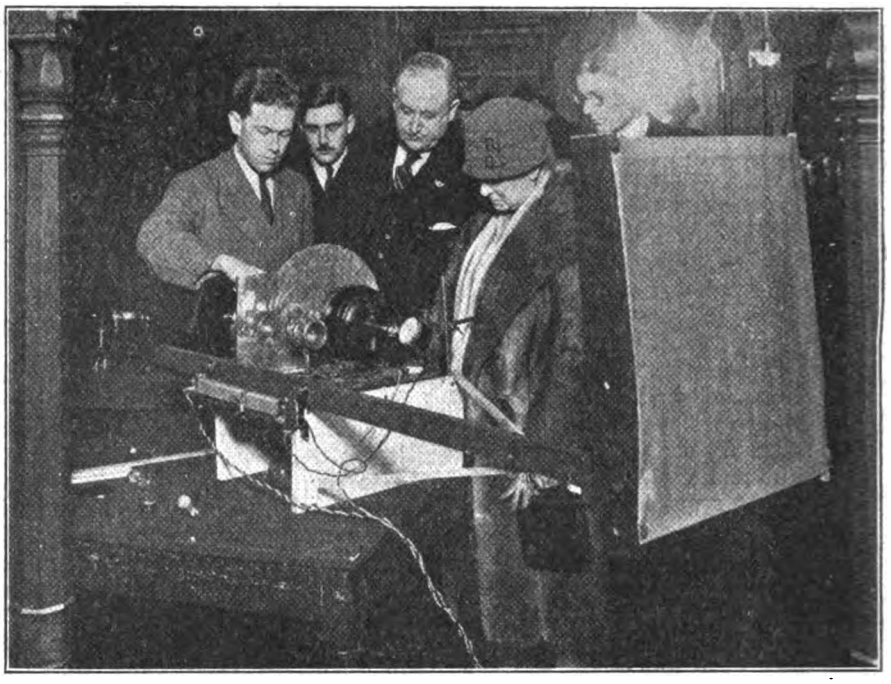
"Bringing the picture in" was quite a fascinating job. On the pink background formed by the glow from the Neon lamp a series of black dots appeared. As the speed of the disc increased they gradually formed dark areas, which next gave place to a distorted image of the shadowgraph being received. When synchronism was attained the image shaped itself into a facsimile of that being transmitted, and had then merely to be held in position by constant, though slight, adjustments of the resistance controlling the speed of the disc.

Interference, such as arose from sparking at the commutator of a motor, or as a result of self-oscillation in the amplifier, caused dark spots and streaks to appear on the pink background, or even distortion of the image.

* * *

Chairman's Remarks.

Dr. Tierney said he was sure that they had all appreciated the description given by Captain Wilson and Mr. Waters of the apparatus. They would all look forward to seeing the lecture reported in the TELEVISION magazine, but he thought it would help everyone who was interested in the apparatus to get ready for the time when broadcast transmissions would be available. He hoped the example set would be followed by many members, and that next session there would be a host of helpful correspondence, constructive criticism and suggested improvements in television receivers. With a host of people working on scanning discs, synchronising methods, etc., it should be possible to find a disc that gave the best results, and a method of synchronising that was simple and effective. Captain Wilson had already indicated suitable lines of experiment, and it only remained for amateurs to follow them up.



Mr. R. R. Poole's exhibit, with which he experimentally demonstrated some features of image scanning.

* * *

The chairman, treasurer and secretary of the Southend-on-Sea and District Television Society, a group centre of the Television Society, were present at the meeting, and Dr. Tierney, in announcing the fact, said that he took this opportunity of extending a very cordial greeting to that Society, and he hoped at the conclusion of the meeting the gentlemen from the Southend-on-Sea Society who were present would give him an opportunity of meeting them and welcoming them personally.

He also took the opportunity of asking them to take to their Society the cordial greetings of the London Section, and the hope that their Centre in Southend would be as successful as the London Centre. Southend was the first to form a local centre, but he understood that others were to be formed in Birmingham, Northampton and Bristol. He hoped that before very long the whole country would be alive to the potentialities of television, and all would be playing their part in these early days of the development of one of the most fascinating of modern sciences.

Standardisation.

The question of the standardisation of various parts used in television had been raised. Strange as it might seem in these days of scientific advancement, the standardisation of electrical fittings did not seem to have advanced very far. They had probably all had the experience of buying a so-called standard 5-amp. plug for an electrical fitting, and getting it home to find that it would not fit. While he was not in favour of standardisation in design, which he believed tended to cause stagnation in development work, he did think it was essential that small parts commonly used should be standardised.

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They would probably be interested to learn that the Council were tackling the matter and were working in co-operation with the British Engineering Standards Association, with a view to arriving at some standardisation of essential television parts and terms.

While Captain Wilson was getting his apparatus ready for demonstration it would save time if Mr. Poole gave his address on scanning. He had much pleasure in calling on him.

* * *

Demonstration of Scanning.

Mr. Poole said he had brought his model along just to show the normal working of a scanning mechanism, and how the detail of a picture was reproduced.

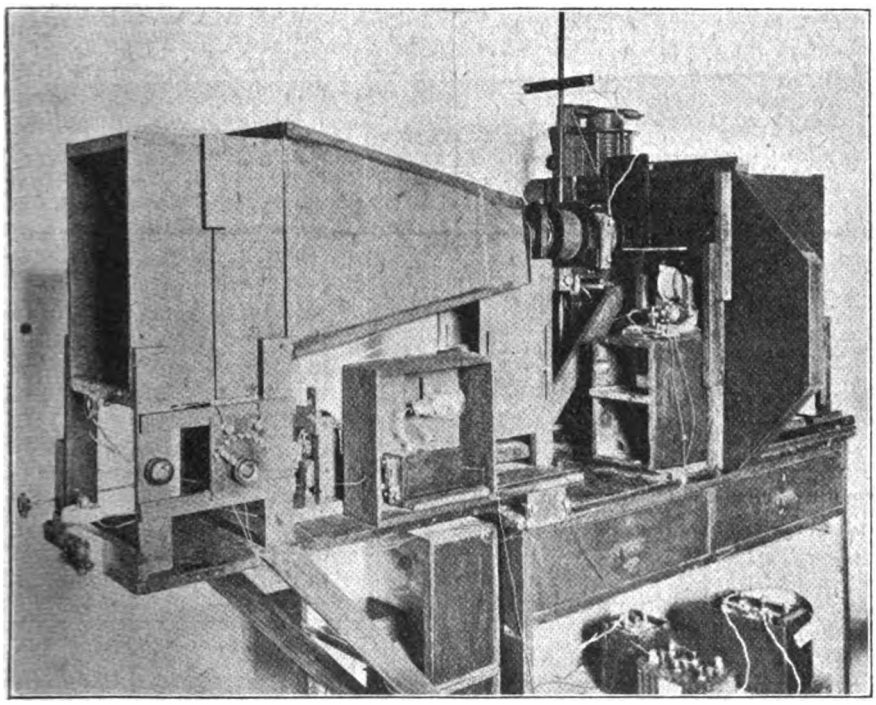
The model consisted essentially of a lantern to provide the light source, a disc rotated by a motor (the disc being made of two parts held together by screws, so that by adjusting one disc in relation to the other, a number of different hole arrangements could be secured), a holder for a lantern slide placed between the disc and the light, and on the other side of the disc an ordinary magic lantern projector lens. A small screen about 18 inches square, on which the lantern slide was projected, was arranged about 3 feet in front of the apparatus, and a revolution counter attached to the motor shaft gave the speed of rotation of the disc.

The first hole-arrangement shown by Mr. Poole was the ordinary spiral at present common in television practice.

Slowly turning the disc by hand with a slide placed in front of the light source, Mr. Poole drew attention to the fact that the image, if they watched the spot of light carefully, was being produced in a series of strips. Starting the motor up, he pointed out that as the speed rose they began to lose the flicker and strippy nature of the picture, and saw it, when a certain critical speed of rotation had been reached, as a complete image.

With the disc he was using there were only 16 holes. They could see that the detail of the picture was quite good, but in practice in a television receiver they would not get such fine detail. It would be severely limited by the size of the holes, although the general appearance would be the same.

The speed at which they saw the picture best without flicker was about 800 r.p.m., which represented, roughly, 16 pictures a second. If the speed was reduced they would come to a point at which flicker began to interfere with the image. That speed was about 10 pictures a second. That was all very well for a still picture, but if there was movement taking place they would experience a form of band distortion.



Experimental Television Projector built by one of our readers, Mr. Fred Taylor, of 58, Clayton Avenue, Wembley, Middlesex.

Peculiar Distortion Effects.

To demonstrate this, Mr. Poole removed the lantern slide and used an ordinary comb. As long as this was stationary it appeared clearly as a comb, but when moved from side to side quickly an appearance as though the teeth of the comb had closed up was given. This, said Mr. Poole, seemed to be due to a sort of heterodyning of the scanning strips of the image with the teeth of the comb.

On the other hand, if he moved the comb up and down a very curious effect was produced. Done slowly the comb looked as though it was bent in the middle into an arched shaped instrument. Done very quickly, the appearance was that either side of the comb jumped up and down in relation to the centre. The back of the comb appeared to wriggle like a snake. This curious distortion of movement, he explained, was due to the fact that by the time each portion of the comb was scanned it had moved in relation to the adjacent portions. The effect was one argument in favour of a high scanning speed, because the movement of the object was less for each scan then than at the slow speed.

The next portion of the demonstration dealt with the scanning method which had been suggested in a paper read before the Society by Mr. Rennie. This was for the arrangement of the holes in the disc in such a way that the scanning started at the centre of the image and ran outwards.

Mr. Poole re-arranged his scanning disc for this method, and showed it first with the lantern slide in position. As between the image produced thus and the previous one with the first disc, at the speed of 16 pictures a second, there was little to distinguish between them. Running slowly, however, with the moving comb in place of the lantern slide, the distortion effects, by reason of the re-arranged scanning holes, were even more marked and weird.

In connection with these experiments, there was one point, said Mr. Poole, to which he would like to draw their attention, and for which he could not offer any explanation. When the scanning disc was running

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slowly the picture appeared to be very much brighter than when the disc was running fast. This was contrary to the statement he had made some time ago.

Effect of Eccentric Spiral.

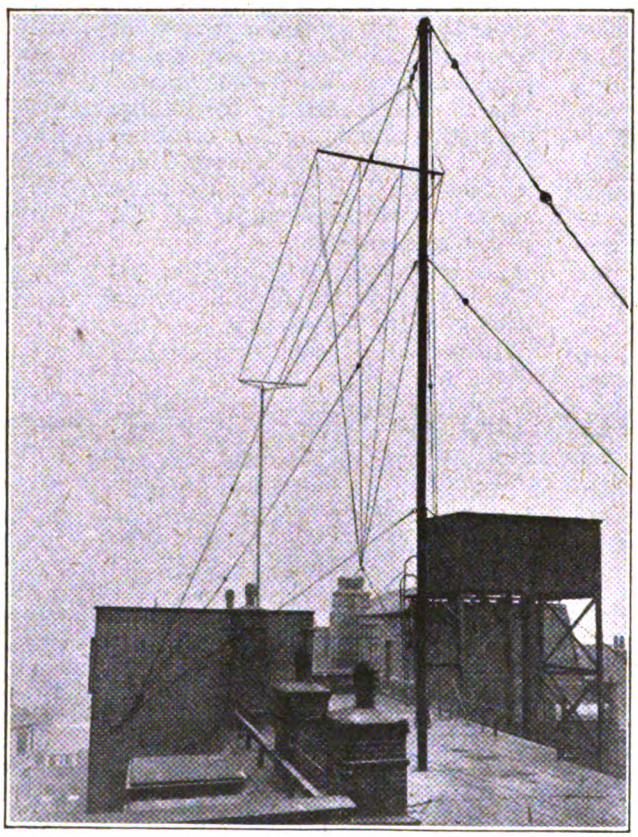
The third scanning method which Mr. Poole demonstrated was with a disc in which the holes were not arranged in a single spiral, but were placed erratically, that is, if one took the disc and examined it one would find that for each revolution it completely scanned the image in the ordinary way, but instead of scanning regularly strip by strip each one adjacent to the next, the image was scanned one strip here, another there, another one perhaps in a different place altogether, the fourth one next to the first one, and so on. With this irregular arrangement, there was practically no difference in the picture, but when run slowly the distortion effects with the comb were even more marked, and made the comb, when moved, appear as though it was built up of a number of sections which were slipping about one on the other.

This final arrangement, he said, seemed to suggest a possible method of securing a certain amount of secrecy in television transmissions, because with a disc of 50 holes the possible number of arrangements was infinite, and anybody trying to look in would find himself faced with a very difficult task if he was going to try out every possible arrangement of holes to find that which was being used. It was, of course, quite obvious that unless the discs at the transmitter and receiver were identical, one could not hope to get an image.

Up to this point, Mr. Poole explained, the lantern slide had been focussed on the screen. He now proposed to focus the hole in the disc, instead of the lantern slide, on the screen. When the disc was slowly rotated they would see that they had lost practically all the detail that the hole had been transmitting, but on running the motor up to speed the picture was still quite recognisable, although it had lost detail in exactly the same manner as they would expect the imperfection of a 16-hole disc to transmit an image in the ordinary television way. In this instance, too, the dark lines between the holes showed up more clearly than was the case when the lantern slide was focussed on the screen.

* * *

When Mr. Poole had finished his demonstration Captain Wilson had his television transmitter and receiver working, and showed an image of the letter X. This was sufficiently distinct to be easily seen across the room, and members were very interested in the apparatus. Long after the meeting had closed Captain Wilson and Mr. Waters were kept busy answering innumerable questions put to them by the group of members who seemed loath to leave.



The transmitting aerial of 2 TV, on the roof of the Baird Laboratories in Long Acre. From this aerial experimental television broadcasts are radiated after midnight.

One Hundred Years from Now.

We are all familiar with the song of that name, but under the same title an anonymous Fellow of the Royal Society indulges in a few flights of fancy in the issue of the *Daily Express* dated May 13th last. He commences by saying that "in this year of grace 2029 it is a revelation to delve into the past and imagine the world as it was one hundred years ago."

After referring to our present-day method of disseminating news "by the quaint means of printing the world's happenings in black type on sheets of paper," the writer goes on to refer to television, under the heading of "Voxavision."

"In the year 1929 the first general broadcast of television, as it was called, took place. The crude, flickering images, colourless and flat, were hailed as outstanding phenomena. To-day we have voxavision, the natural development of television, with its stereoscopic depth, natural colour and perfect reproduction.

"News, entertainment and outstanding events are obtained at will by a slight variation of wavelength, and are supplied by what were formerly the great newspaper syndicates.

"Every home is so equipped, and thus the world's happenings are 'on tap,' so to speak. In equatorial regions, as at the Poles, one can see and hear the Derby, and watching and listening to opera while hurtling through space at 600 miles per hour, at a height of eight miles, is commonplace."

Book of the Pye

The above is the title of a very interesting and beautifully produced brochure (in colour) which has just been issued by Messrs. Pye Radio, Ltd., of Cambridge, whose London address is Paris House, Oxford Circus, W. 1. Readers can obtain a copy on application to Messrs. Pye.

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As One Woman to Another ——About Television.

By ANNETTE BUCKLEY.

THIS article is not written for the men-folk; there is enough material elsewhere in this magazine for them to get on with, plenty of high-brow technical jargon which they can afterwards reel off to a dazed and somewhat awed female audience round the family fireside. Photo-electric scanning discs and synchronisers and things. You see what I mean? You've all heard it, all you wives and sisters of subscribers to TELEVISION.

So I've persuaded the Editor that it's high time he allowed me to write something of interest to these sisters and wives. I know the menfolk won't thank me for it. They'd far rather see the space devoted to a further article about those photo-electric synchronisers and things, and, besides, it will be *so* irritating, just when they want to settle down to Professor Cheshire's next article, to find that one of the womenfolk has pinched TELEVISION and started to read this little effort of mine.

* * *

And now, to work.

I suspect that you, dear (female) reader, and I are in the same boat. How many times have we heard our menfolk discuss and almost harp on the subject of television! And how many times have we questioned and cross-questioned in an effort to pierce the barrage of unintelligible technicalities with which this mysterious subject seems to be surrounded. I haven't the slightest doubt, my dears, that you failed as miserably as I did. The men, poor things, simply can *not* condescend from their exclusive heights for a moment to explain to us the mysteries of something which, so they would have us believe, only their superior intellects (*sic*) can comprehend.

So I decided to go and find out about this thing for myself. Of course, I had to get my brother to help me. He has a pal whose sister's sweetheart's cousin is "something in the Baird Company." I forget the relationship exactly. Anyway, I got a pass to go and witness a demonstration of television at Mr. Baird's studios in London.

I was ever so thrilled. I was so "het up" about it (my brother's just back from the States. Yankee slang is *so* expressive, don't you think?) I couldn't sleep a wink the night before and had to visit a beauty parlour before I was even *fit* to be seen. You know how it is.

As a result I was late, of course. But they were ever so nice about it—at the Baird studios, I mean. They even kept a deputation from the War Office waiting until I was out of the way.

Until I attended this demonstration I had only the haziest notion what television really is—no more idea than you probably have at this minute. Now I know that television enables us to see over *enormous* distances by means of electricity. Wonderful thing, electricity, isn't it? It can do such perfectly *marvellous* things. I do think those automatic electric cookers—the Editor will use up some more blue pencil in a minute if I don't watch out.

We can, of course, see what is going on several miles away by means of a telescope, but the range of a telescope, according to my brother, who used to be a Boy Scout, is "distinctly limited by the curvature of the earth and the density of the atmosphere." I hope you can all understand what he means. I can't. He says that's due to the density of my head. But brothers always are rude.

Anyway, television doesn't suffer from these limitations. I was told that it is now possible by means of television to see something which is happening *thousands* of miles away. Just *think* what a marvellous boon it will be to us to be able to see on the screen of a machine in our own homes those wonderful creations which only Paris can produce!

Those of us who are needlewomen need no longer experience the miseries of a Channel crossing (I'm such a *rotten* sailor, and my brother simply howls at me *so* unsympathetically) in order to gain some inspiration for that new summer frock. As to expense, I was told it will be cheaper to stay at home and buy a televisor (that's what they call the receiving gadget), for the thing won't cost more than a really posh loud speaker! And you'll probably be able to buy one on the instalment plan, too; but don't all of you order at once, for I don't know if Mr. Baird has yet acquired a fleet of "plain vans!"

However, I'm incurring the risk of the displeasure of that editorial blue pencil again, and I'm sure you are all bursting to know what happened at my demonstration. I call it "my demonstration" because I had it all to myself. That is, practically all to myself. There were several other people present. Anyway——

* * *

On arriving at the studio I was met by ever such a nice old Commissionaire—you know the type? Such a kindly twinkle in his eyes. And I bet he could have told such thrilling yarns about wars and things. But he didn't. He was all efficiency. "Name, please? Have you an appointment?" I mentioned the name of the cousin of my brother's pal's sister's sweetheart, and all was well. The said cousin was sent for,

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and I was shown into the demonstration room.

This room, I found, was quite small, capable of holding perhaps a dozen people. On a raised platform at one end there were two televisors of what I was told are the "dual" type. That means, that besides the television screen, there is a loud speaker and two wireless receivers to work them, one receiver for each.

You've all seen photographs of the machine in TELEVISION, so I needn't give a detailed description of it here. On the top left of the cabinet is the loud speaker, and on the top right is the television screen. You both hear *and* see what is happening at the sending end.

But the cabinet, my dears! Really, I was surprised. All the world knows Mr. Baird is a Scotsman, and yet he puts his apparatus in a most marvellous mahogany case! You know what that means. Another piece of furniture to ronuk.

There were four or five other people present, and after a few words of explanation the demonstrator switched the light off, leaving the room illuminated only by the rays of a red lamp. I began to get really thrilled. It all seemed so queer and wonderful. Then there appeared on the screen a sort of pinkish light marked with faint vertical strips.

All of a sudden, and quite clearly, I realised that I was looking at a grotesque sort of face. The demonstrator explained that this was the head of a doll which was used for tuning-in purposes. Incidentally, these clever menfolk who interest themselves in wireless mysteries never seem to be able to rid us of the bugbear of tuning-in, do they? They seem to love that preliminary fiddling about, which is so annoying, and I feel convinced they wouldn't abolish it, even if they could. My brother says it would take all the joy out of life, like depriving a woman of the joy of trying on innumerable hats. Of course, he *would* be catty.

Well, when they got this doll quite clear, the demonstrator phoned through to the transmitting studio, and in place of the doll there appeared the head and shoulders view of—Oh, gee! *Such* a handsome young fellow! Simply gorgeous. You've no *idea* how my poor heart fluttered as he turned his head and looked at me. I had to pinch myself and remember that he was looking at me through a machine and couldn't actually see me. Then he rolled his eyes at me—and completely spoiled the effect by announcing through the loud speaker that he was doing so in order to demonstrate the ability of the apparatus to show the whites of his eyes. I don't know which is the worst, soulless machines or men. I already knew the abilities of the machine, for I had noted a perfectly adorable dimple on his chin.

I have come to the conclusion that the Powers That Be deliberately

Two Mexican delegates to the secret Postal Union Congress, at present being held in London, witness a demonstration of television at the Baird Studios.

postponed regular television broadcasting till July, until after the General Election is safely over, in case the handsome election candidate should capture the new flapper vote on his looks alone.

Anyway, if those musty old election broadcasts included television pictures of the speakers, and the flappers saw what I saw, actual politics would not influence their votes in the least. For, what do you think? Not content with causing my heart to flutter by the sight of his face alone, this handsome young Apollo suddenly began to sing—and Oh, the beauty of that liquid voice! It held me spellbound for so long I did not realise a girl had taken his place.

She was now talking and laughing, and the man next to me shuffled and edged his way closer, pulled his tie straight, and buttoned those two fatal lower buttons of his waistcoat, the approaching middle-age spread of which can never be hidden. He adjusted his *pince-nez* and looked till that stocks-and-shares look gradually faded, leaving an appearance of supreme bliss on his robust countenance. Wonderful thing, this television.

This "turn," of course, did not interest me so much, so I took the opportunity to relax a little, as you will have guessed from the above observations. Still, it was all very wonderful, and I was ever so thrilled.

Then there was an interval of a few minutes while they adjusted "the works." So far, we had only seen a head and shoulders view of the person being televised (I'm getting quite technical, aren't I?) After the readjustment we were to see more.

In a few minutes the screen flickered into life again, and we saw a full three-quarter length view of my shiekh, this time seated before a grand piano, the full length of the keyboard of which we could see quite clearly. Was it possible that he could also play the piano? Yea, even so. More, he accompanied himself in song, and once again I heard those liquid tones . . . Yes, I know you're all dying to hear about it, but really there are some things too sacred. . . . Anyway, he has a most *marvellous* technique. I saw it—through the televisor.

Then we heard—and saw—a quartet. They were good, and we could see all four, three-quarter length, as clear as clear.

* * *

I came away from that demonstration with my head in a whirl. I thought of the enormous difference television would make to broadcasting—to be able to *see* as well as hear. And I thought about my shiekh. . . . My brother was *very* unkind about it. . . .

However, I see that editorial blue pencil hovering again, so I must save all my thoughts till next month . . . Editor permitting.

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THE CONSTRUCTION OF EXPERIMENTAL TELEVISION APPARATUS

By A. A. WATERS

Mr. Waters, in collaboration with Captain F. Wilson, recently demonstrated before the Television Society a Shadowgraph Transmitter and Receiver which they had designed and constructed.

The following article is the first of a series which Mr. Waters will write for "Television," giving constructional details of interest to amateurs.

FOR the construction of apparatus for carrying out experimental work of any kind certain tools and equipment are necessary. As a result of my experience in this direction I have made the following resolution: never to buy or install any gear which is not really essential.

My reason for this is that in most amateur workshops the space available is very limited and it is very easy to fall into the bad habit of losing or mislaying an article which is wanted to finish off some piece of apparatus you are making. So, in the first of this series of articles, I propose to deal only with tools and equipment that are absolutely necessary to the experimenter.

B.A. THREADS.

No.	Tapping drill No.	Clearing drill No.	Outside dia. over thread.	No. of threads per inch.
0	8	B	·23	25·4
1	16	3	·209	28·2
2	24	12	·185	31·4
3	29	19	·161	34·8
4	32	27	·142	38·5
5	36	30	·126	43·0
6	43	33	·110	47·9
7	46	38	·098	52·9
8	50	43	·087	59·1

Fig. 1.

Essential Tools Required.

One of the chief tools required is a vice with 3-inch jaws; I have found by experience that the small type of vice usually sold for half-a-crown or so is practically useless for holding the parts one has to construct in television apparatus. Hence I would advise spending a few extra shillings in obtaining a good vice.

The jaws of most vices are serrated and are apt to mark the particular job held between them, so it is desirable to make a covering for them. Such coverings should be made from scrap tin or aluminium, and are called "vice clamps."

The next tools required are a wheel-brace and drills. In my workshop I have a small chart hanging over the bench, with sizes of drills required for tapping and clearing holes, and I have illustrated this in Fig. 1. It will be found quite a useful asset if pasted on a piece of cardboard and kept where it can be seen at a glance. Of course, one does not need all the sizes of drills and taps shown on the chart, so I suggest as the three most useful sizes the following: 2BA, 4BA, and 6BA.

Some "Don'ts."

Do not attempt to drill small holes with a large wheel-brace, otherwise you will find your drills will break with the weight of the brace. For this reason the brace should not hold a drill larger than ¼-inch diameter. If larger holes are required a larger size of brace must be used.

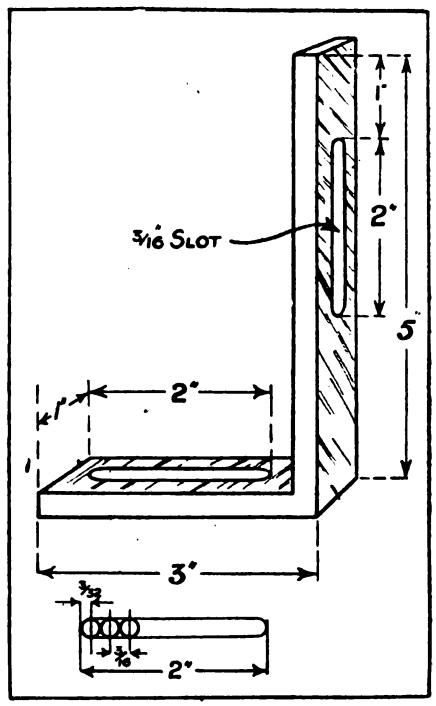

Fig. 2.—The two brackets.

Another very important tool is the tap wrench. I have often seen amateurs trying to use a tap with a pair of pliers, almost always breaking the tap. Tap wrenches can be bought from one shilling upwards and well pay for themselves.

The next item one should have is an adjustable hacksaw frame and saws. Never be without a spare hacksaw blade, as one of the most annoying things that can happen is

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to get half-way through a job, break your saw, and find it is the last one you have. One should also possess a centre punch and a scriber.

We next come to the question of files and, as these are quite inexpensive, I should advise the constructor to obtain the following:—

One 8-inch flat smooth file.
One 8-inch flat rough file.
One 8-inch pillar file.
One $\frac{1}{8}$-inch square file.
One $\frac{3}{16}$-inch round smooth file.

As an example of the tools required for a typical job we will consider the construction of a piece of apparatus which will be found very useful in a television receiver—an adjustable neon lamp holder.

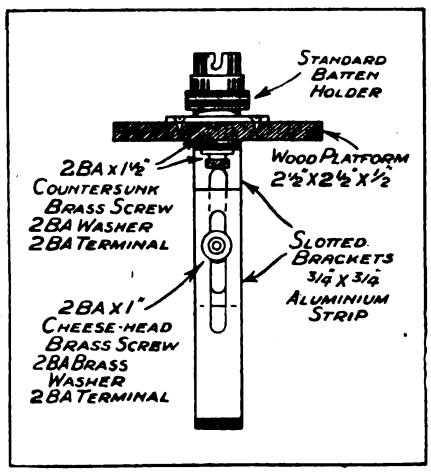

Fig. 3.—General arrangement of Neon Lamp holder.

The first step is to obtain the required materials, which are as follows:—

2 feet of $\frac{3}{4}$-inch × $\frac{1}{4}$-inch strip aluminium.
1 2BA × 1-inch Ch. Hd. (Cheese Head) screw.
1 2BA × 1½-inch Csk. (Countersunk) screw.
2 2BA brass washers.
2 2BA terminal heads.
1 standard batten holder.
1 piece wood, 2½ × 2½ × ½ inches.
3 $\frac{3}{8}$-inch No. 4 brass wood screws.

Making the Brackets.

First, the strip aluminium should be cut to a length of 8¼ inches; the extra ¼ inch being to allow for the bend. Take note that the brackets are the same.

Then with the scriber mark a line 3⅜ inches from one end, and bend the strip at right angles at this mark. The material should be held in the vice and bent with the aid of a hammer. Now mark off the position of the slots. I expect you will think it difficult to get these slots cut, but with a little care it can be done quite easily, thus:

With the scriber and centre punch mark off the slots as shown in Fig. 2, and drill with a $\frac{3}{16}$-inch drill. Then, using a $\frac{3}{16}$-inch round file, file these holes through into one another. If the constructor does not like to file the slots the holes can be used for adjustment, but of course this means taking out the screw each time, and it is not possible to adjust so finely as when a slot is used.

Simple Assembly.

We next take the piece of wood and drill and countersink a $\frac{3}{16}$-inch hole in the centre, as shown in the drawing of the general arrangement, Fig. 3.

The assembly does not require any explaining if one follows the diagram carefully.

I think the experimenter will find this small piece of apparatus very useful, as in my experiments with scanning discs of different sorts I have found it essential to adjust the neon lamp very carefully.

In my next article I will describe the scanning discs used in shadowgraph experiments, and will give details as to their construction.

International Activities of the Baird Company

There has been but little news of late concerning the foreign interests of the Baird Company, so with a view to ascertaining what really is going on our representative interviewed one of the Baird Company's officials. It would appear that our enquiries were somewhat too premature, for the official concerned explained that he was unable at the moment to give us more than a bare outline of the position. We learned, however, sufficient to convince us that the Baird Company at the present time is extremely active abroad.

FRANCE.—Our readers are already familiar with the progress that has been made in France. We hear all goes well and that some extremely interesting information will shortly be released to the public.

GERMANY.—As our readers know, the Baird Company's engineers have been over in Germany for some weeks. Some very satisfactory tests have been made through a German broadcasting station before officials of the Government, and the Germans seem determined that their country shall be the first to broadcast regular television programmes.

AUSTRALIA.—The Baird Australian group is making considerable progress with the Australian Government. The Baird contingent is headed by Major Maculich, who formerly represented the Dunlop Company's interests in Australia.

CANADA.—On February 4th last Sir John Aird, chairman of the Canadian Royal Commission on Radio Investigation (which was over here to study European broadcasting conditions), witnessed a demonstration of the Baird system of television, as a result of which he reported on his return to Canada that "England has advanced further than even the Americans in television."

SOUTH AFRICA.—We understand that South Africa is to be given an opportunity of witnessing demonstrations of the Baird system of television in July next.

NEW ZEALAND.—Negotiations are in active progress in New Zealand, and we understand that the Government is definitely interested.

CZECHOSLOVAKIA.—Interest in the wireless world is at present centred on Prague, where a conference of the Union Internationale de Radiophonie is being held to settle the question of the international allocation of broadcast wavelengths.

M. Braillard, chairman of the Technical Committee of the Conference, came especially to London for a demonstration of the Baird system of television, and he expressed himself as being immensely impressed. Judging from his remarks, we expect he will advocate the allocation of certain wavelengths for television broadcasting purposes.

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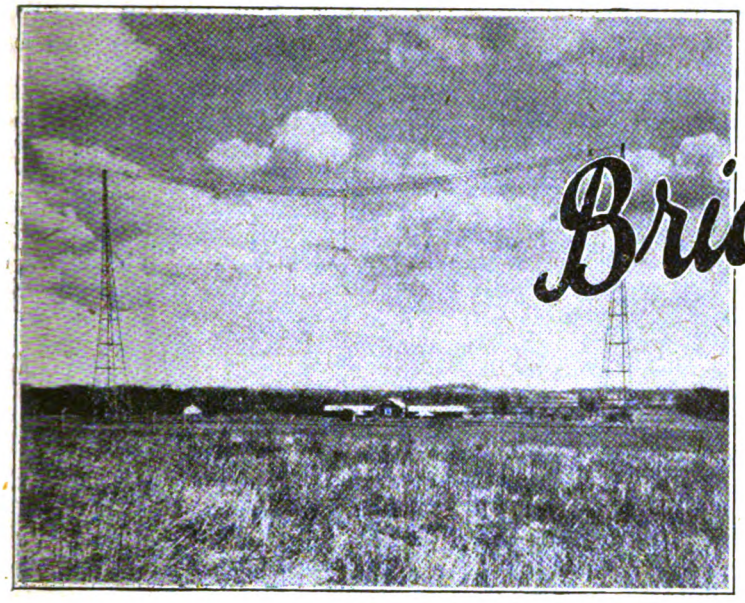

Bridging Space

by

JOHN. WISEMAN

Part XII.—AMPLIFICATION

THE main factors appertaining to high-frequency amplification were dealt with quite briefly last month, so that in this article we shall turn our attention to a consideration of what takes place in the amplification process after the incoming wireless signals have been rectified.

We have seen how amplification is brought about inside the valve itself, and realise that the function of the impedance in the plate circuit is to resist changes of anode current, and thus make any signal at the grid reproduce itself in the form of the largest fluctuation of anode potential.

Making up a Note of Music.

Now, when dealing with high frequencies it is easy to press into service a tuned circuit to function as our high impedance, or use a high-frequency choke, but after rectification the currents flowing, although still of a pulsating nature, are now operating at what we term low frequencies—that is, low in the wireless sense. We must realise that a musical note is not a simple vibration at one frequency but a combination of vibrations at frequencies which have a simple relation one to another. The lowest, called the fundamental, gives the pitch, and the others, termed harmonics, impart tone and quality. We may say that normal musical vibrations have a frequency range from 25 to 10,000 cycles per second.

To avoid any form of distortion in low-frequency amplification the process must be carried out in such a manner that the increased signal differs from the original only in being greater in magnitude. For speech or music purposes, therefore, it is essential that all electrical currents corresponding to notes from 25 to 10,000 cycles should be amplified equally (and television falls within the same category) and, furthermore, the apparatus chosen for this purpose must in no way introduce notes not in the original broadcast or break up the televised figure.

Valve Requirements.

Turning for a moment to the valve itself, the above requirements are met if the output current in the plate circuit is directly proportional to the input grid voltage. We can ensure this by seeing that the input grid-volts swing to each valve operates within the straight portion of the valve's characteristic curve.

In addition, it should never touch the zero grid-volts line; neither should it pass beyond the limits of the straight part of the curve. To see how this operates, examine the curves shown in Fig. 1, *AB* representing a typical characteristic curve for a power valve. If we assume that the chosen working position for the valve is represented by the negative grid bias at *O*, then we can see the effect of various input grid-volts.

If the signal handled by the grid is as curve (1) then it is easy to see

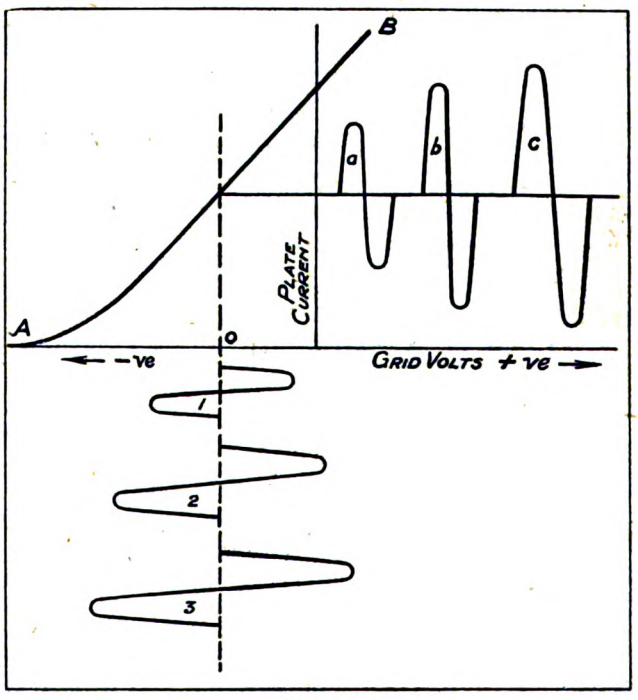

Fig. 1.
Typical valve curves.

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that the current change as indicated by curve (*a*) is directly proportional to the input curve (1) and the signal

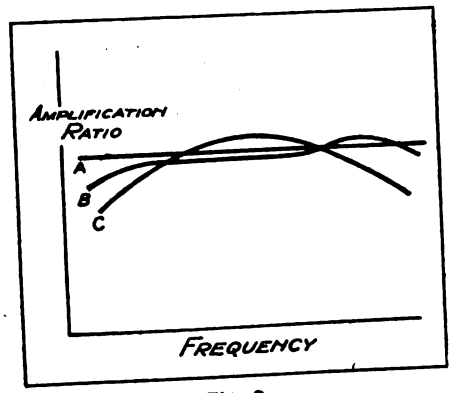


Fig. 2.
Some examples of transformer curves.

is amplified faithfully. With curve (2), however, there is a greater increase of anode current from normal than there is decrease owing to the grid swing excursion on to the bottom bend of the characteristic curve. This lack of matching will bring about a distorted signal in the plate circuit, see (*b*), while the larger input curve (3) would make matters still worse, for in addition to an excursion on to the curved part of the valve characteristic, the grid swing is shown large enough to make the grid acquire a positive voltage, and thus cause a grid current to flow. Any form of gross overloading such as this can only be cured by using a valve with a long enough straight characteristic to handle the full grid swing such as, for example, an LS5A.

Two Essentials to Watch.

Incorrect negative bias on the valve may also cause distortion. That is, one can use too much and

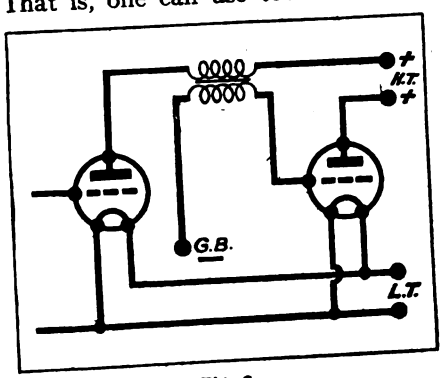
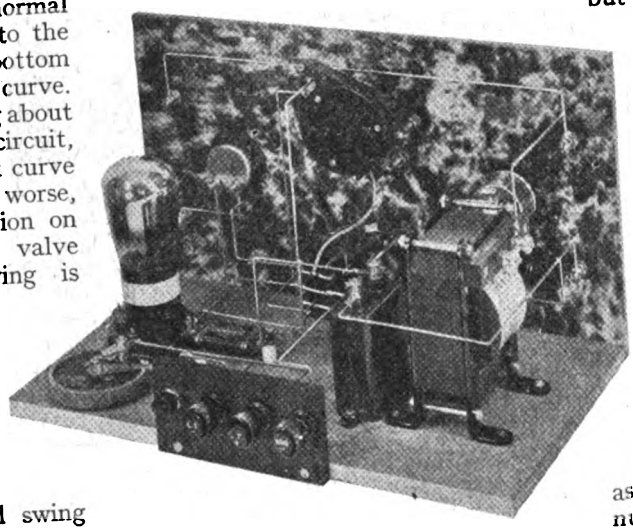


Fig. 3.
Transformer coupling.

work on the lower bend of the characteristic, or too little and cause grid current to flow. Two essentials which must be watched, therefore, are the choice of a valve (or valves of course) capable of handling adequately the input voltage swing and the application of the correct negative grid bias. This latter value generally can be determined from the valve data supplied with each valve on the printed slip in the containing carton.

We are now in a position to pass from the valve and pay attention to the form of coupling to be employed when using valves in cascade. We saw at the beginning of the article that the frequencies to be dealt with vary from about 25 to 10,000 cycles per second, so that the form of coupling which was suitable for high-frequency amplification would be useless in low-



A typical choke-coupled amplifier.

frequency amplifiers owing to the enormous reduction in frequency (it being remembered that, except in the case of a pure resistance, frequency has a considerable bearing on the resultant impedance of a particular circuit).

Popular Forms of L.F. Coupling.

There are three well-known and popular forms of low-frequency coupling open to the choice of the individual, although combinations of these give rise also to other forms which, however, are generally not so efficient and in any case are outside the scope of this article. These couplings are known as low-frequency transformer, low-frequency choke, and resistance capacity, and each can be made to give very good service.

Naturally, each of these three is

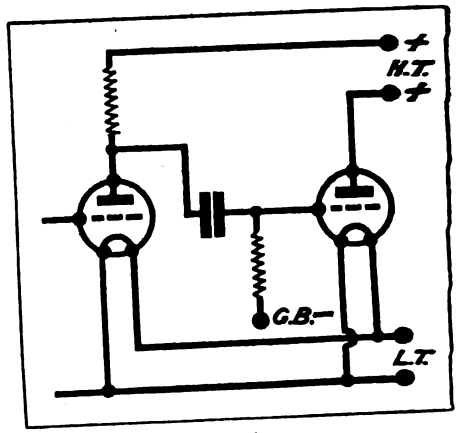


Fig. 4.
Resistance—capacity coupling.

characterised by its own peculiarities, but a good performance will be forthcoming if reliable components are used and the correct values are chosen. Controversy has raged from the very early days of wireless as to the respective merits and demerits of each form of coupling, and no doubt it will continue to do so; but to condemn one and to laud another would appear futile since in many cases it is found that a combination of at least two gives the nearest approach to ideal results.

With the low-frequency transformer one has the advantage of an amplification step-up as the result of any excess in the number of turns on the secondary winding as compared to that on the primary winding. Since the essential portions of this particular component are a laminated iron core and coils

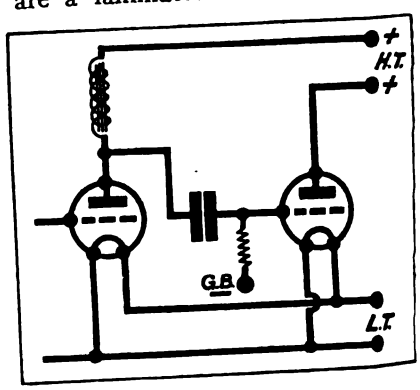


Fig. 5.
Choke coupling

mounted close to one another, it is at first thought that the resultant

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impedance in the plate circuit can in no way be constant, owing to the presence of the iron. This, however, is not the case owing to other factors creeping in, such as self-capacity, leakage field, etc., and transformers made by firms of repute, where skilled design and artisanship can be used with advantage, indicate a reasonably constant amplification for all frequencies within the usual acoustical range.

A Point to Note.

The curves of Fig. 2 show what is meant, for whereas *A* represents the ideal case, *B* is drawn for a high-class transformer, while *C* is that for a transformer of poor quality, and shows how the high and low notes are amplified much less than those of medium pitch. It is important to watch that the mean plate current for the particular grid bias chosen is not too great, otherwise there may be a considerable reduction in the value of the primary winding inductance due to a change in the properties of the iron.

Fig. 3 shows the usual diagrammatic way of indicating a transformer coupling between two valves, one end of the primary winding being joined to the plate of the first valve, and the other end to H.T.+, while the secondary winding has one end joined to the grid of the succeeding valve with the remaining end connected to the appropriate negative grid bias voltage. While the early types of transformers proved to be a source of perpetual distortion, the attention that has been given to the design of this component at the present time has resulted in an instrument capable of remarkably even amplification over the bulk of the musical scale.

Resistance Capacity Coupling.

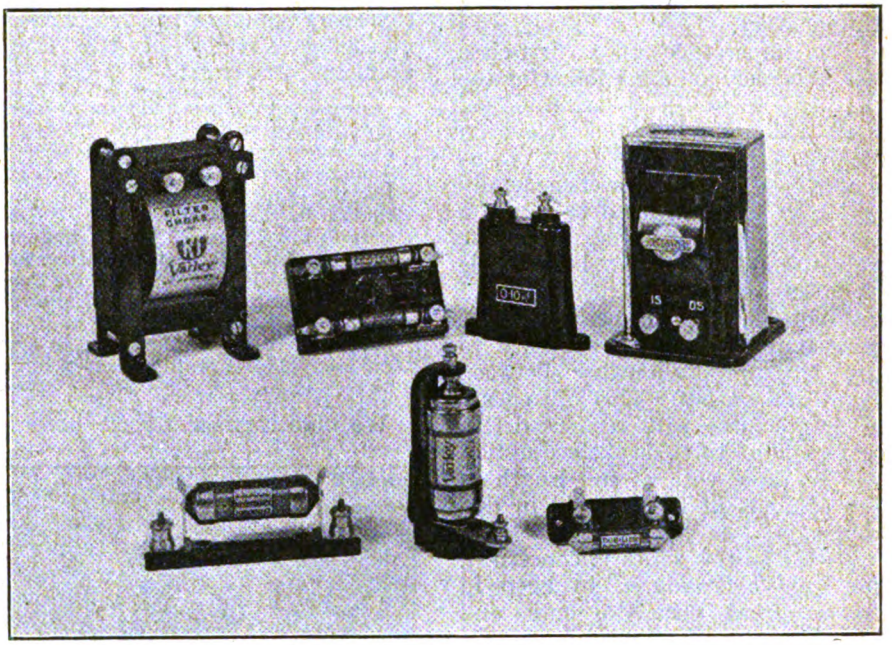
With resistance capacity coupling many different points arise owing to the complete dissimilarity between this and the previous coupling we have discussed. Fig. 4 shows the bare essentials of a resistance capacity stage, a resistance generally of the wire wound non-inductive type being included in the plate circuit of the first valve, while a fixed condenser is used to couple the plate of this valve to the grid of the next valve, negative grid bias being applied through a grid leak of predetermined value joined to a G.B. battery.

Since it is possible to incorporate in the plate circuit a resistance of the non-inductive type it would seem that perfect straight line amplification would be attainable owing to the constancy of the impedance irrespective of the frequency. The snag, however, lies in the fact that a fixed condenser must be utilised to couple the two valves together, and here is a component whose impedance alters with frequency.

In spite of this, a resistance capacity coupled amplifier is capable of giving really faithful reproduction, and as far as the coupling condenser is concerned one of the conditions to be fulfilled to ensure full amplification of the low notes is that the capacity should be large compared with the grid-to-filament capacity of the valve to the grid of which it is connected. R.C. Coupling has come into its own through the marketing of special high impedance, high ampliacation factor valves for the purpose, as in the earlier days an inherent disadvantage was present, due to the impossibility of getting the same amount of amplification per stage as with transformer coupling.

The Secret of Success.

It will be seen that with resistance capacity coupling the maximum amplification possible is limited to the amplification factor of the valve, whereas with the transformer a step-up can be gained. The real secret of successful R.C. amplifiers lies primarily in the choice of suitable valves and component values, and generally speaking the anode resistance should be about four or five times the valve impedance, while the grid leak can conveniently be made about four times the anode resistance. Apart from the actual value of the coupling condenser, it is essential to use one with first. class insulation, otherwise the high tension battery will be connected direct to the grid of the valve.



A group of components, such as are described in this article, which are in general use for coupling the various of stages of L.F. amplifier.

An excellent combination is provided by using a stage of R.C. coupling, followed by a stage of transformer coupling, and by discreet component choice the resultant amplification curve leaves little to be desired from the dual standpoint of magnitude and evenness. The third type of coupling mentioned, namely, choke capacity, resembles resistance capacity, the only difference being the substitution of a low-frequency or iron cored choke for the wire wound anode resistance (see Fig. 5), and a typical L.F. choke coupling stage is illustrated in one of the accompanying photographs. The ample size of the iron core is a point to notice, otherwise faithfulness of reproduction is liable to be at a discount. Another photograph shows a collection of low-frequency coupling components such as can be

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Bridging Space*—*continued.

used with confidence in making up the L.F. side of a wireless receiving set.

In Conclusion.

When dealing with large powers in the output stage of the receiver it is advisable generally to include some form of "filter circuit" such as an output transformer or low-frequency choke and fixed condenser, as damage to the loudspeaker is prevented by isolating the relatively large output currents from the delicate windings and, furthermore, no risk of a shock is involved when handling the speaker.

The importance of a first-class low-frequency amplifier following the detector valve in a wireless set used for receiving the television broadcasts cannot be over-emphasised. Large powers generally will have to be handled to secure a really good picture, so that the valves employed must be capable of dealing adequately with the input grid-volts swing, but perhaps more important still is the necessity to get true proportionality between input and output. This will ensure a picture alive with realistic detail, and no doubt this side of the question will be dealt with at full length in the columns of this journal in due course.

As far as this series is concerned, we have endeavoured to keep in the forefront principles only, and in consequence important details have had to be neglected. It is to be hoped, however, that the reader will now be in a better position to picture, mentally, what is happening between the broadcasting studio and the actual receiving set, and thereby reveal a greater and more intelligent interest in the process as a whole.

Short Wave Miracles.

G5SW, at Chelmsford, England, recently rebroadcast a short-wave program from PHI of Huizen, Holland, by way of the United States. General Electric radio engineers, experimenting at a receiving station a few miles outside of Schenectady picked up the Dutch short-wave station and rebroadcast the program of music. Engineers at G5SW picked up W2XAF, rebroadcasting PHI and rebroadcast the program. Engineers of W2XAF tuned to the English station and heard the program after its third trip across the Atlantic.

Important Pronouncement by the Baird Co.

During the course of the March meeting of the Television Society a suggestion was unanimously adopted to the effect that the secretary of the Society should write to the Editor of TELEVISION and ask for the publication of more constructional articles.

Many readers have also written to us independently, making similar requests.

At the April meeting of the Television Society the following letter, signed by Captain O. G. Hutchinson, managing director of the Baird Company, was read :—

> At present we have under construction about 4,000 televisor sets. These are due for delivery before the middle of June next, and will, therefore, be ready by the time the Brookman's Park Station has been completed.
>
> It is our intention to sell these as complete units, but later on further lots may be sold in complete kits for those who wish to assemble them themselves.
>
> With regard to delivery of these machines, it is our intention to give preferential treatment to members of the Television Society.

We ourselves have since been in communication with the Baird Company and have received the following communication from the secretary :—

> Dear Sir,
>
> In answer to your enquiries for data and specifications of the Baird Televisor receivers, we would refer you to Captain Hutchinson's communication addressed to the Television Society of April 9th.
>
> The Baird Television Development Company, which is interested in the development of Baird inventions in Great Britain and Ireland, has also considerable interests in Baird International Television, Limited, which Company was formed for the purpose of exploiting the Baird system of television in foreign countries. Any action which the Development Company may decide to take from time to time must necessarily be governed by the interests of the International Company.*
>
> I should be glad if you would bring to the attention of your readers that it is the Development Company's intention to release with the Baird Televisor receivers the necessary instructions for the satisfactory reception of television, as and when public television transmissions commence.
>
> Yours faithfully,
>
> BAIRD TELEVISION DEVELOPMENT CO.
> (Signed) T. W. BARTLETT, *Secretary.*

*(Elsewhere in this issue will be found a brief statement on the activities of the Baird International Television, Limited, in various foreign countries.—ED.)

AN HISTORIC PHOTOGRAPH.

The above photograph, received just on going to press, was taken on the occasion of the recent successful demonstrations of the Baird system of television in Berlin to the Directors and chief technicians of the German Post Office and of the Rundfunk Gesellschaft (the German Broadcasting Co.). In our next issue we shall be able to give the names and descriptions of those present.

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The Optical Specification of Optical Glasses—Spectroscopy

Part XI

By Professor CHESHIRE, C.B.E., A.R.C.S., F.I.P.

THE question is often asked: "What is optical glass and how does it differ from ordinary glass?" It may be said at once that any glass which is clear, colourless, and homogeneous in structure may be used in a limited way for optical purposes. But, as in engineering constructions, a large number of different metals and alloys are needed with a wide range of physical properties so, in the case of optical constructions, a large number of different glasses are needed with a wide range of optical properties. Glass, then, is to the optician what metal is to the engineer. A good modern catalogue of optical glasses, such as that of Chance Bros., will usually be found to list about a hundred or more different kinds of optical glasses.

The optical constants of each glass are tabulated as in the following examples taken from Chance's list for 1919, involving, as will be seen by inspection, the experimental determination of the refractive indices of four of Fraunhofer's lines, viz., *C*, *D*, *F*, and G^1 for each glass listed.

In practice the probability is that no glass could be obtained to the exact specifications set out in the catalogue. The figures are those which are realised as nearly as it is possibly to do so in successive meltings. Thus the nearness to which, for the work of the optical designer, a manufacturer can reproduce the catalogued data for a given glass is a very important matter. If they are realised closely and constantly an optical system, such as that found in a microscope objective, for example, can be made from successive meltings to the same curves and therefore with the same tools; otherwise recomputing and new tools may be necessary.

The physical significance of the various optical qualities numerically expressed in a glass catalogue, and as set out in the examples above, can be understood best, perhaps, from a consideration of the following experiment.

An image of a slit *S*, upon which an image of the sun is focused, is projected by a lens upon a screen in a darkened room. If a thin wedge or prism of the glass under examination be now placed against the projecting lens, as in Newton's experiment, the various colours of the sunlight falling upon the prism from the slit and lens

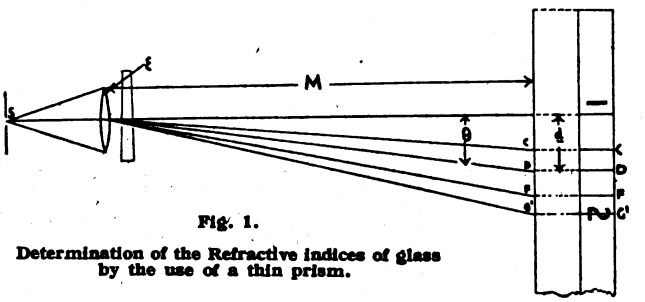

Fig. 1.

Determination of the Refractive Indices of glass by the use of a thin prism.

will be dispersed, or spread out, into a narrow band or spectrum of the rainbow colours, in which the red is produced by the rays least bent, and the violet and blue by those rays which are most bent.

The solar spectrum thus produced, if the slit is narrow, is mapped out with reference to certain fine dark lines, already referred to (see the issue of TELEVISION for May, 1929) as the Fraunhofer lines. The particular lines generally used for the specification of the refractive and dispersive powers of optical glasses are the *C*, *F*, and G^1 lines of the hydrogen spectrum, and the *D*-line of the sodium. In earlier catalogues the line A^1 of potassium—near to the solar line *A*—was also used.

Suppose now that the refracting angle of the prism is small and equal to ε, and that the prism is placed at a distance *M* from the wall, and further that the *D*-line under these circumstances is refracted through an angle θ, corresponding as shown to a distance *d*, on a vertical scale, then $\theta = d/D$, and since the angle ε of the prism is by assumption very small we have also $\theta = \varepsilon(n-1)$, where *n* is the refractive index for the sodium line *D*, for the glass under test.

If then ε is made equal to the reciprocal of *M*, and *M* conveniently is made equal to a metre—100 cm.—then $\varepsilon = 1/100$ so that finally we have $d = n-1$. It follows from this

Optical Glass Types (CHANCE).

Type No.	Variety of glass.	n_D.	Mean dispersion. C to F. (Δ)	V. $\frac{n_D-1}{\Delta}$	Partial dispersions and relative partial dispersions. (δ_1) C to D.	(δ_2). D to F.	(δ_3). F to G^1.	Sp. gr.
646	Boro-silicate Crown	1·5087	·00793	64·1	·00237 ·299	·00556 ·701	·00445 ·561	2·46
3829	Telescope Crown ..	1·5153	·00858	60·0	·00254 ·296	·00604 ·704	·00485 ·565	2·50
4277	Telescope Flint ..	1·5237	·01003	52·2	·00295 ·294	·00708 ·706	·00575 ·573	2·67
7972	Very dense Flint ..	1·7566	·02754	27·5	·00774 ·281	·01980 ·719	·01736 ·630	4·82

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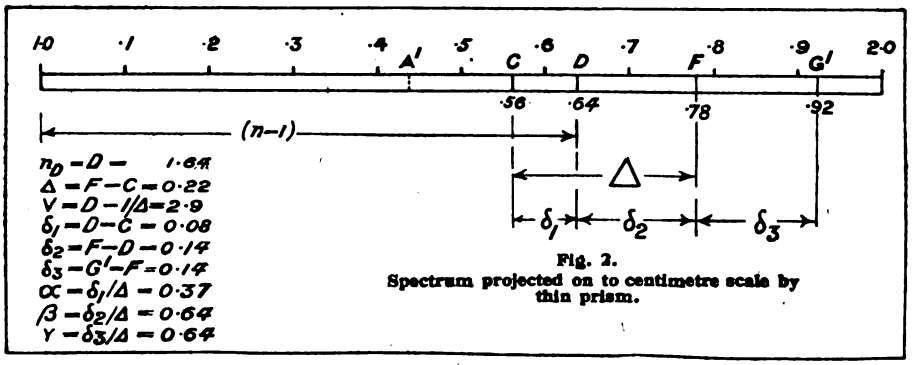

Fig. 2.
Spectrum projected on to centimetre scale by thin prism.

equation that, using a thin prism, the deflection produced is directly proportional to the excess of the refractive index of the glass over that of air itself, assumed as unity, so that by using a horizontal slit *S*, and allowing the spectrum to be formed at a distance of 100 cm. on a centimetre scale, suspended vertically, so that its graduation "1" coincides with the projected image of the slit, before the prism is introduced, the refractive index of any line or colour in the spectrum produced by the prism can be read off directly in centimetres.

For any line or colour found on the 1·5 cm. division, for example, the glass of the prism must have a refractive index of 1·5.

The use of a thin prism for determining the refractive indices of the selected lines of the spectrum in the way indicated would be of little use in practice—much more complicated apparatus is required to get the necessary accuracy. In the case of the last glass on our list, for example—the very dense flint—the four lines *C* to G^1 would all fall on our scale between the divisions 1·7 to 1·8. We will, therefore, for the sake of clearness and simplicity deal with a supposititious glass, one with very great dispersive power.

Suppose then that for this glass we first find by experiment that the refractive indices for the lines *C*, *D*, *F* and G^1 are 1·56, 1·64, 1·78 and 1·92 respectively. Our thin prism would then disperse these lines so that they would fall on our centimetre scale in the positions shown by Fig. 2. We can now mark off the distances $n-1$ (the distance between 1 and the position of the *D*-line) and the separations Δ, δ_1, δ_2 and δ_3.

As a simple matter of addition, subtraction, and division we can now derive the optical data required for the successive columns of our catalogue. This has been done to the left of Fig. 2. The three quantities α, β and γ, known as the relative partial dispersions are equal to δ_1, δ_2 and δ_3, divided in succession by the mean dispersion Δ.

In practice sunlight is rarely or never used. The necessary lines are obtained from incandescent hydrogen and the sodium flame. Some makers also utilise the A^1 line of potassium, which occurs near to the *A*-line of Fraunhofer.

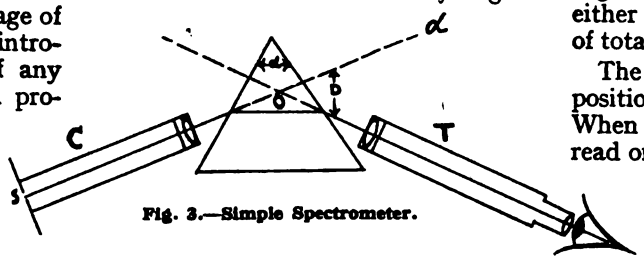

Fig. 3.—Simple Spectrometer.

Spectroscopes and Spectrometers.

Apparatus for the investigation of the spectrum and the determination of the refractive indices of its various lines, as dispersed by different media, are amongst the most interesting and important of optical instruments. Many different types are now in use, but Fig. 3 shows in principle the oldest and best known of these.

A prism of glass, or in some cases quartz, is made with its angles as true and its faces as flat as possible. This prism is placed upon the rotatable table of a spectroscope provided with a fixed radial collimator *C*. An observing telescope *T*, also mounted radially, is adapted to rotate in a horizontal plane about a vertical axis *O*.

If the refractive index of the glass for the sodium line, say, is required, a sodium flame is placed near the slit *S*, and the bundles of parallel rays, emerging from the collimator, fall upon and are refracted twice by the prism before they enter the observing telescope *T*. The prism and the telescope are then adjusted by trial until it is found that the slightest rotation of the prism, in either direction, increases the angle of total deviation *D*.

The prism is then said to be in the position of "minimum deviation." When in this position the angle is read off in a circular graduated scale, and the refracting angle α of the prism being known, the refractive index *n* of the sodium light is got from:—

$$n = \frac{\text{Sin}\,(\alpha + D)}{\text{Sin}\,\frac{\alpha}{2}}$$

In a beautiful modern modification of this spectrometer the collimator and the observing telescope are fixed rigidly at right angles to one another. A specially shaped prism is employed, which, as it is rotated about a vertical axis, causes the spectrum of the light collimated to

(*Continued on page* 203.)

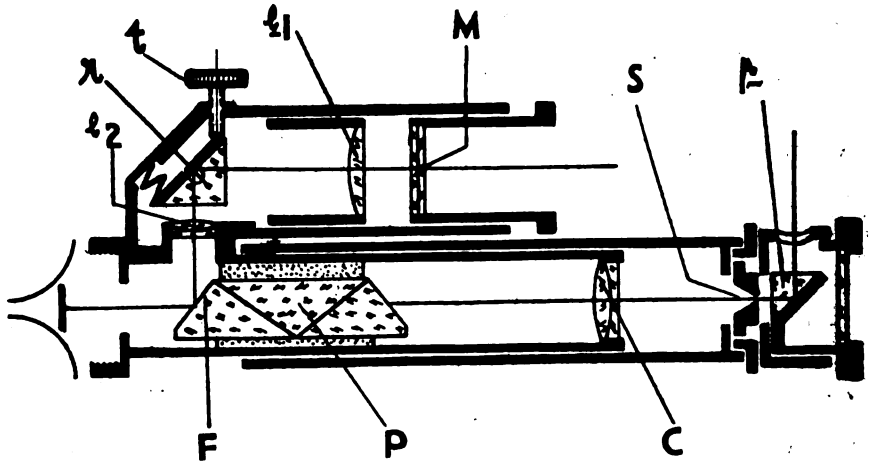

Fig. 4.—Section of Hand Spectroscope

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The Story of Chemistry

Part IX

Atomic Structure

By W. F. F. SHEARCROFT, B.Sc., A.I.C.

IN last month's article a slip passed uncorrected, when on p. 135, as a correspondent kindly points out, it is stated that a "sulphate ion consists of the atom SO_4 bearing a positive charge." It should, of course, be a *negative charge*.

The ions to which the previous article referred were those produced during the solution of electrolytes in water. The word ions has, however, a wider significance than this. The atom as we suppose it to be constructed consists of a central nucleus around which are arranged particles much as the planets are arranged round the sun. The central particle is made of protons or positive electricity; the planetary bodies are the electrons, individual units of negative electricity. Each kind of atom is a more or less stable system of electrons and protons.

For every proton in the nucleus there is an electron outside it, so that electrically the atom is neutral. The electrons, it appears, are not arranged anyhow in the atom. It was supposed at one time that they just moved in the sphere of influence of the central nucleus, but further consideration has inclined us to the belief that the spacing of the electrons will follow a law of some kind.

Bohr, in 1913, developed a theory in which the movement of the nucleus as well as the electrons was taken into account. It is not a case of the electrons revolving round the nucleus, but of both revolving round a common centre of gravity. Later, Sommerfeld introduced the conception of elliptical orbits in place of the circular ones on which Bohr worked. From such assumptions as these theories provided, the mathematician was able to work out the possible orbits. From this point the theory dives into the realms of higher mathematics, and becomes much too complex for treatment here. The latest development is the discovery that the electron has associated with it waves, or possibly it may be a wave itself. Someone has said that it is best to think of the electron as a wave for three days of the week, and as a mass of electricity for the other three—giving it one day's rest a week, presumably!

From a chemical point of view we get another aspect. Here we are concerned not so much with the movement of the electrons as with their relative positions. It is supposed that the electrons in any atom will arrange themselves in zones or shells. The first shell, nearest the nucleus, will contain two electrons as a maximum. If the atom contains more than two electrons then these will go into the next zone up to a total of 8. After that another zone of eight will be formed, to be followed by two zones of eighteen, and one of thirty-two. Hydrogen consists of a nucleus of one proton and one electron. Helium consists of two protons and two electrons, both in one zone. Neon, the gas which fills the famous

A CORNER OF THE BAIRD LABORATORIES.

All wireless components used in the construction of amplifiers, etc., are carefully tested before being used in connection with television experiments.

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neon tubes, has ten electrons arranged in one zone of two and an outer zone of eight. Sodium has eleven electrons, two in the first zone, eight in the second, and a solitary one in an outside zone.

Now the chemical properties, which we measure and by which we recognise substances, depend upon the outside zone of electrons. The ordinary chemical operations never penetrate below this zone. It is further considered that an element with an outer zone of two or eight electrons represents a very stable condition, a condition in which the atom is quite content with its state, and resists very strongly any attempt to alter it. This is confirmed with neon with an outer layer of eight electrons. Chemically the element is inert. It does not enter into any combination, and no compounds are known. The same applies to helium with its outer zone of two electrons.

Atoms which are not in this happy position are looked upon as striving to attain it. Considering the atom of sodium—it has an outer zone of one electron, the next inner zone containing its full complement of eight. There are two ways in which the sodium atom could attain to the supposed state of maximum stability. It must either add on to it seven other electrons, and so complete its outer ring, or it must lose the one solitary electron, and leave an outer ring of eight.

The atom of chlorine has seventeen electrons, which, according to this theory, would be arranged in an inner zone of two, a middle zone of eight, and an outer zone of seven. To reach the ideal state of stability it is enough for the chlorine atom to add on one electron to its outer sheath.

It is a fact that sodium and chlorine unite readily, and here we see a sensible explanation of what we mean by combination. Sodium wants to lose an electron, chlorine wants to gain one. When the two atoms chance to be in suitable circumstances they mutually supply each other's wants. The sodium atom loses its electron to the chlorine atom, and then both become atomically stable.

But the loss of an electron upsets the electrical neutrality of an atom. Directly the sodium atom loses an electron, then as a whole it becomes positively charged—there are no longer enough planetary electrons to balance the charge on the nucleus. Such an atomic residue which has become charged by the loss of an electron is called a positive ion. The sodium atoms in this state are sodium ions. Similarly the electron gained by the chlorine atom will upset the electrical balance of that atom, making the negative charges associated with it greater than the positive charge of the nucleus, and thus the modified atom will exhibit a positive charge. We say that the chlorine atom, as it now is, is a positive ion. We can then suppose that in virtue of their opposite charges the two ions become associated together, to form the molecule we call sodium chloride.

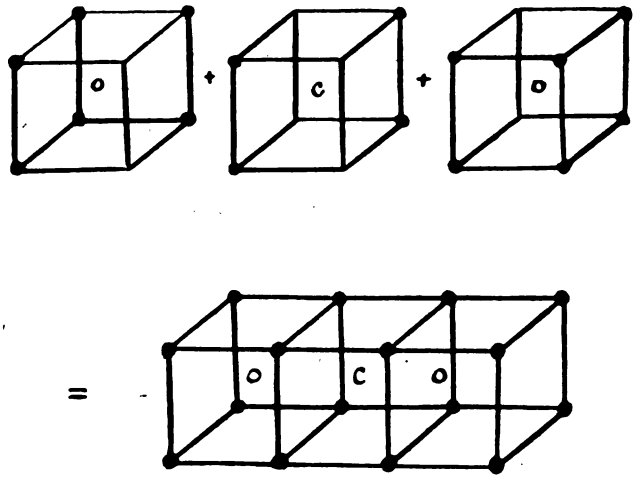

Fig. 1.—Diagram representing the union of oxygen and carbon to form carbon dioxide.

It will be noticed that both sodium and chlorine need to lose or gain *one* electron to achieve the configuration of electrons which denote stability. Both these substances are univalent, returning to the conception of valency as one of the factors of chemical combination. Valency due to this initial loss or gain of electrons is known as *electrovalency*. Ionisation takes place prior to combination.

Oxygen, we know, has a valency of two, which may be explained similarly. The oxygen atom has eight electrons associated with it, two in the first zone, and six in the outer sheath. To complete its outer sheath it adds on two when opportunity presents, and becomes an oxygen ion. Calcium, with twenty electrons, will have an outer sheath of two. If it loses those it becomes a divalent ion, possessing an outer sheath of the stable arrangement of eight electrons. The calcium ion will be positively charged, the oxygen ion negatively charged, and the two may enter into combination to form calcium oxide as a result.

It is recognised, however, that electrovalency does not account for all cases of combination. Thus the union of oxygen and carbon is represented as in Fig. 1. Here only the outer sheath of electrons is represented, and the electron is shown as a dot occupying the corners of cubes which are supposed to surround the atomic nucleus and the other zones of electrons. It will be seen that the arrangement of atoms after combinations is such that, by mutual sharing, each nucleus is finally surrounded by the complete sheath of eight electrons. This sharing of a pair of electrons is described as *Covalency*.

It must not be imagined that these views, outlined here very briefly, have solved all the chemist's problems about chemical combination. There are still difficulties and many points which await solutions, but it is strange that these latest theories bring back memories of ideas a century or more old, ideas which for a long time have been given up as useless. Electrovalency seems very much akin to the idea of Berzelius who, a hundred years ago, suggested that chemical combination was the union of oppositely charged radicles. A later type-theory is analagous to the idea of covalency, in which the composition is a structure.

Consideration of these ions and the structure of the atoms, has led us back to a still older idea, one perhaps which we may detect faintly in the earliest speculations of philosophy. The simplest atom of which we know anything is the hydrogen atom. It consists of one proton and one electron. The next simplest is the helium atom with two electrons and two protons. We have very cogent reasons for believing that we have not missed anything between

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them, and the obvious connection stares us in the face—the helium atom is but two hydrogen atoms united together. The word "united" in that statement may have more than its usual significance, but, if only we knew how, we could make two hydrogen atoms from one helium atom.

The study of the structure of other atoms has extended this conception, and now we believe that all atoms are built up of the fundamental hydrogen unit. It is probably not a simple addition process; in fact we know that it cannot be. There is some packing effect which may even result in the destruction of matter as such, but every known atom is still a multiple of the hydrogen atom, and thus, in the twentieth century, hydrogen is established as the primordial substance of which the universe is constructed.

This suggestion was advanced in 1815 by the English chemist Prout, who based his assumption on the fact that the atomic weights of many of the elements were whole numbers, when that of hydrogen was taken as unity, and as the unit of measurement. He argued, therefore, that it was probable from this that the other atoms were but aggregates of hydrogen, atoms. The results then available were subject to frequent revision as new and better methods and apparatus became available, and Prout expected that the future would show that the atomic weights of those elements which were not whole numbers would prove to be such with further research, and more accurate determinations.

This speculation, however, proved fruitless, although it attracted considerable attention. It was proved beyond doubt by experiments so carefully carried out that the limits of error could be definitely stated that the atomic weight of an element such a chlorine was not as whole number, and that no future refinement in the determination would ever make it a whole number. In view of such conclusions, about which there could be no doubt, Prout's hypothesis became merely of historical interest. It remained for a later age to resolve the apparent contradiction, by a brilliant piece of work which must be left for a future contribution.

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Optical Specification.

(*Concluded from page* 200.)

pass across the vertical cross-wire in the eye-piece of the observing telescope, under the condition that the spectrum line or light found on the cross-wires at any instant is light which has passd through the equivalent prism at the minimum angle of deviation.

The setting for minimum deviation is thus effected automatically by the bringing of the desired spectrum line on to the cross-wires of the telescope. A graduated drum giving directly the wave-length of the line or light under observation is linked to the mechanism for rotating the prism.

Hand Spectroscope.

Fig. 4 from the catalogue of Carl Zeiss shows in section a hand spectroscope of the (John) Browning type, which is an invaluable laboratory instrument for the approximate determination by inspection of the wave-lengths of the light transmitted by colour filters, and emitted by flames, etc.

The light under test, passing through the slit S, is collimated by the lens C, so that bundles of parallel rays from each point of the slit pass through the direct-vision prism P, and are angularly dispersed by it—the red to one side of the line of sight and the blue to the other. These dispersed beams *of parallel rays* enter the eye and produce the spectrum of the light under observation. A wave-length scale is projected simultaneously upon the spectrum in the following way:—

An empirically drawn wave-length scale M, is mounted in a tube so as to be adjustable longitudinally with respect to a collimating and reflecting system l_1, r and l_2. Parallel bundles of rays from each point of the scale M are thus reflected to the eye by the exit or last face (F) of the direct-vision prism P, and give the wave-length scale superposed upon the projected spectrum, thus enabling the observer to read off directly the wave-length of any line or part of the spectrum seen.

The operation of a screw t tilts the mirror r, and thus longitudinally traverses the wave-length scale on the spectrum for adjustment.

By covering half of the length of the slit S with a small right-angle prism p, two spectra can be simultaneously projected and compared—one being seen above the other.

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The Psychology of Empire Television

By H. ANTHONY HANKEY, Fellow of the Television Society

The writer of the following article received recognition at the last Imperial Conference in connection with Empire Broadcasting. He is a well-known pioneer in the wireless world and a staunch supporter of Empire Communication, having done much to further its development.

UPON being questioned by the Press regarding the possibilities of television, at the conclusion of an Empire tour last year, I stated that it would be a commercial proposition inside five years. This was in the ordinary sequence of things. I was case-hardened and, therefore, cautious, not realising that even as I spoke television had practically "arrived."

It is probable that those who are most intimately connected with all forms of communication (and television certainly comes under this heading) are the last to admit that any specific scientific attainment is imminent. I recall the late managing director of a world-wide organisation telling me that he did not wish to know too much about technicalities as the accompanying difficulties would tend to blind his vision. However this may be, knowing full well how increasingly important all methods of communication are to the present and each succeeding generation, one has to accept the fact that television has come to stay.

It is not necessary to enlarge upon the gratification to be derived from an actual view of the speaker, performer or event in addition to hearing the sounds received by wire or wireless *as the performance takes place*. This vivid pleasure, even amounting to a thrill, could be evidenced in comparatively local transmission and reception, but I am considering it in a much broader sense than that.

Those of us who have been separated from our friends and relatives by great distances realise the anxieties attendant upon an absence of knowledge concerning current events. Often weeks elapse before a satisfactory reply can be received to some intimate or urgent enquiry, and even though one is able to telegraph and telephone, such communication is devoid of that personal touch which is so essentially desirable.

I venture to state that Empire migration, with its illimitable benefits to the British nation, as well as to the individual, would increase enormously if the potential settlers could know that they might occasionally speak with and see their Home folks. Even the fact of being able to view a topical event *actually taking place* in their Homeland would give that indefinable feeling of "contact" which means so much to the exile.

Mr. HANKEY before the microphone at 3LO, Melbourne.

This was experienced by my wife, during my absence in the Dominions, in a speech I broadcast from my cabin on the *Demosthenes* in Sydney Harbour last year; the talk was radiated through the Sydney station, 2FC, and received on short-wave apparatus, with a few feet of aerial, just outside London.

One was, even then, within an ace of being "viewed" at the same time. There was a certain amount of voice "fading" as the best period of transmission was not available, due to 2FC having prior arrangements, but even then the vision would have averaged quite well and completed the sense of contact as far as is humanly possible.

Assuredly most of our present problems are associated with organisation and vested interests rather than with technicalities. It is not difficult to envisage the tuning-in of a moving panorama depicting lumbering in Canada, the Victoria Falls on the Zambesi River, a Zulu war dance, an ostrich farm, vignettes of the railway from Mombasa to Victoria Nyanza, the Taj Mahal at Agra, a street scene in Cairo, a tea plantation in Ceylon, or a picture of life in Malaysia and China. There are practically no limits, within reasonable areas, to the "shots" which can be transmitted from overseas and received in the Homeland in the near future.

It is realised that the popular imagination has only just been stirred at the moment; indeed, until quite recently there have been so many conflicting reports regarding the practicability of television that this state of affairs is not surprising.

Then again, strange as it may seem, there appears to be an enormous section of the public which confuses television with still-picture transmission. In the course of many lectures which I have given upon television during the last few months, this lack of discrimination has been only too apparent. Possibly things develop so rapidly now that the man in the street suffers from mental indigestion in this progressive age. Certain it is, however, that as nothing succeeds like success, an enormous fillip will be given to the domestic radio world in the course of this year, due to one of the most modest inventors of the day, whose achievements will be supplemented by the activities of hundreds of enthusiastic amateurs, as in the case of short-wave broadcasting.

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The Spotlight Principle in Television

By NORMAN J. NICOLSON.

In the following article the writer makes some most interesting observations on the spotlight system of television, and gives some hitherto unpublished information and illustrations.

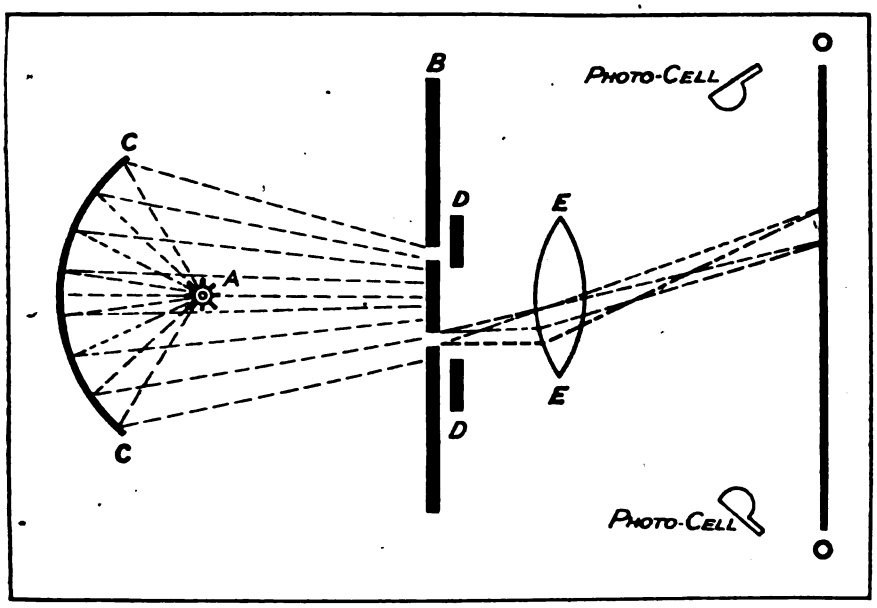

Fig. 1.
Diagrammatic representation of the arrangment of a spotlight television transmitter.

IT is now fairly common knowledge in television circles that the only proved successful system of transmitting vision electrically, either by wire or wireless, is that invented by Mr. J. L. Baird, which embodies, as one of its basic principles, his method of scanning the images or scenes by a spot of light.

In common with many other superficially and easily absorbed ideas, this simple subject offers abundant food for concentrated thought, and the writer's object is to explain fully the process employed by Mr. Baird, together with some of the associated developments, and the difficulties encountered in harnessing this method to the science of television.

It is proposed, firstly, to describe the theoretical layout of the apparatus needed to project a suitable television spotlight. This will be understood better when studied in connection with Fig. 1.

Here we see a source of brilliant illumination (*a*), in front of which is situated a revolving disc (*b*) perforated with a number of square holes in the form of a staggered spiral, as illustrated in Fig. 2. The position of the disc is so arranged that as it rotates all the holes are equally in the path of the rays from the light. Reverting to Fig. 1, (*c*) is a concave reflector placed behind the illuminant, to direct its rays on to the disc ; (*d*) represents a gate control which is necessary to prevent the spots overlapping on the screen.

Transmitter Details.

Each spot, naturally, should have left the screen at the precise moment that the following spot begins its traversal. (*e*) Is a focusing lens, which we may say receives the spot through the disc and projects a concentrated edition of it on to the image to its maximum intensity at any required distance within its range limits.

Studying the diagram, it should be quite apparent that, as the disc revolves, the image will be scanned by a spot which resolves itself into a succession of narrow strips of light, and these, owing to the rapidity of the operation, combine to form what to the eye appears to be an even band of illumination, with perhaps a slight discernible flicker.

The actual perforations in our disc may here be dwelt upon. We have stated that these are square, and so, in practice, they are, but examining Fig. 2 closely, it will be brought home to the thoughtful reader that these apertures, owing to their spiral arrangement, should theoretically be wedge-shaped, with the inner and outer edges very slightly curved, as shown enlarged in Fig. 3, and the area of the inner hole of the series should be slightly smaller than that of the outer, and those between the two should vary proportionately.

Square vs. Round Holes.

The advantages to be gained by using perfectly shaped holes are, however, entirely insufficient to warrant the endeavour to surmount the mechanical difficulties attendant on producing discs so perforated. Thus,

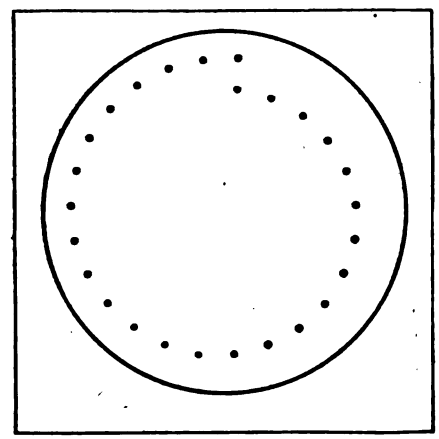

Fig. 2.
The spirally perforated scanning disc.

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America is content to use round holes, the easiest to construct, in both transmitting and receiving discs; but in this country square holes have been adopted as standard, mainly because at any given moment the amount of light passing through a square hole is greater than that passing through a round hole for a definite

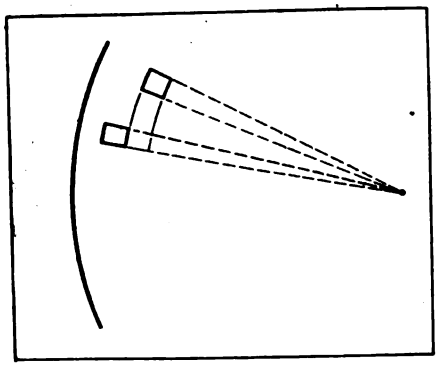

Fig. 3.
Ideal perforations, as explained in the text.

breadth. This is easily proved by referring to Fig. 4, where the area of 1, 2, 3, 4, is AB^2, and the area of the circle is $AB^2 \times \cdot 7854$.

Proceeding further, we will study the process of converting our light spot during its travels into electrical impulses. This brings us to that "open sesame" of television, the photo-electric cell. It is not proposed to discuss in this article the evolution or construction of the cell, as we know it, as this might well form the subject of a separate and lengthier article, but we will deal with it purely from the view-point of its application to television.

Fig. 5.
An attempt to illustrate a stationary image being scanned by spotlight. Where the holes of the scanning disc join up perfectly in a vertical direction no grain is visible, but a very small inaccuracy in size is shown by whitish lines when they overlap, and by dark lines when they underlap. An effort has been made to accentuate these conditions in the above picture, so that they shall show up clearly in the reproduction.

The Photoelectric Cell.

Its *modus operandi* is that, provided a sufficient potential is applied across its anode and cathode current will flow in proportion to the light values to which it is exposed, and no matter how rapidly these values fluctuate there is no appreciable lag in the response of the cell in converting them into current impulses. We must consider this quality in conjunction with the fact that everything encountered by our light spot in its traversals will reflect that light at its own particular value, a white object reflecting more light than a black one, and so on.

Thus we can see how, by placing photo-electric cells in close proximity to the image which our spot is scanning, electrical impulses will be set up in response to each strip as it is described, the current value of the impulses depending upon the reflective properties of the subject being televised. The result is that one revolution of the disc covers the subject with a sequence of light strips (according to its number of perforations); these are dealt with in turn by the cell or cells, and we can visualise our image as being transformed into terms of fluctuating current and so made available for transmission, either by wire or wireless.

Naturally, in order to obtain what, to the eye, will appear a moving picture, fifteen or more images must be produced per second, and so our spot must scan the object with this rapidity. An attempt has been made to illustrate in the accompanying photograph a stationary image (Fig. 5) being scanned by spotlight. It is possible from this to trace the grain formed by the spot's traversals.

Distortion.

It may prove of interest at this point to consider the question of the distortion which is directly traceable to the spotlight method of scanning. This must obviously take place in cases where we endeavour to televise objects whose detail is extremely small in relation to the size of the spot.

A common instance is lettering below a certain size. By following the example given in Fig. 6, it will be seen that the crossbar of the T is reproduced accurately until the spot travels down (*a*) and (*b*) and encounters part of the crossbar together with half of the upright portion of the letter. The result during these two sweeps in the cell is

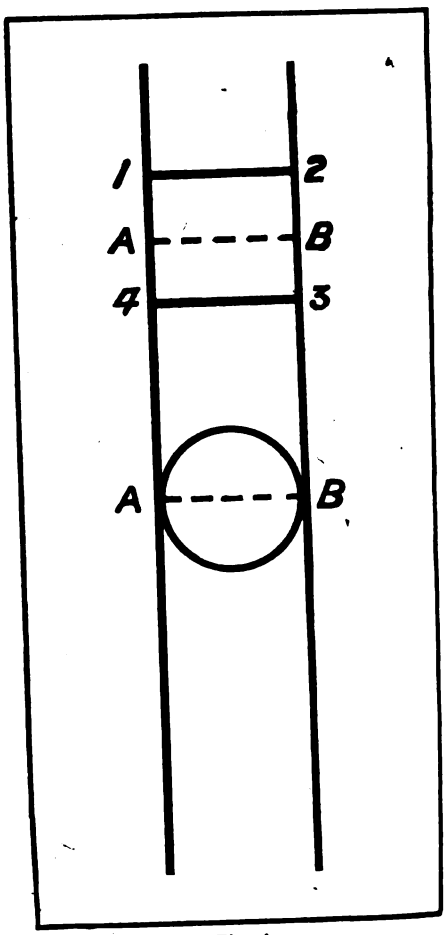

Fig. 4.
Showing diagrammatically how more light, and better definition, can be obtained by using a square hole in preference to a round one.

a mean value in current impulse, with the consequence that our reproduction is something like (*c*).

Small, round or non-uniform shapes are also subject to this kind of distortion on standard screens.* The

* Moreover, wherever the spot encounters a sharply-defined outline, there is bound to be a point when, having travelled half-way across it, a mean value in current will be set up in the cell, and the same applies when it is leaving an outline. This building-up and dying-away effect sounds more serious than it actually is in practice, but nevertheless it is a factor which must be taken into account. Sharp outlines are always softened thereby.

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obvious mitigation of this difficulty is to increase the number of holes in the transmitting disc, making the spot smaller and the grain of the screen finer; but doing this would involve us in difficulties in other directions, although it is safe to predict that this will be the ultimate trend of development.

At the same time, it is remarkable in practice how tolerant and self-accommodating the human eye is towards this kind of distortion, and objects which theoretically one would imagine to be distorted beyond recognition when televised come out with extraordinary clarity. This is especially the case when the object is moved about whilst being displayed. Students of the art of cinematography will appreciate this phenomenon quite easily, as it is shared by both sciences.

Amplification Problems.

We must here devote some attention to the problem of amplification in television. The current fluctuations produced in a cell are at their best very minute and require a large amount of initial amplifying, before they can be transmitted.

The maximum frequency to which the amplifier must respond is the aggregate of all the current values produced by the cell per second, so that to calculate this we must multiply the number of holes in the transmitting disc by the number of pictures per second, and again by a factor which will be different for every object televised, i.e., the mean variation in light and shade in the light strips described by the spot. There is also a very low frequency to be taken into account and which the amplifier must be capable of handling.

Fifteen times per second, or as many times as there are pictures per second, certain current values set up in the cells from the object will recur, and as these can be any frequency from zero, our bottom frequency may be as low as fifteen. This, of course, is capable of a more adequate analysis mathematically. The chief point to be realised is that television has to progress hand in hand with amplifiers (amongst other things) which must respond evenly over a range of frequencies from around fifteen to upwards of 10,000 per second under existing conditions, and should a finer grain be aimed at in our images, then the top frequencies will be even higher.

Virgin Field for Amateurs.

So what is more or less a virgin field in the realm of amplifiers is open to research workers. A loss of low frequencies causes undesirable dark shadows to be present. Pure white and shiny surfaces tend to throw these up to a certain degree. At the other extreme a loss of high frequencies causes white shadows or halo effects over the image.

Before closing this article it is perhaps advisable to indicate to readers just how the scanning principle is applied to daylight television, as we must admit that the art will have a rather limited scope for its application unless we can foresee the time arriving when televising topical events under ordinary conditions will be an accomplished fact. Let me assure readers right away that there are no insuperable difficulties in the way of reproducing living scenes in the open air and that daylight television has already been accomplished.

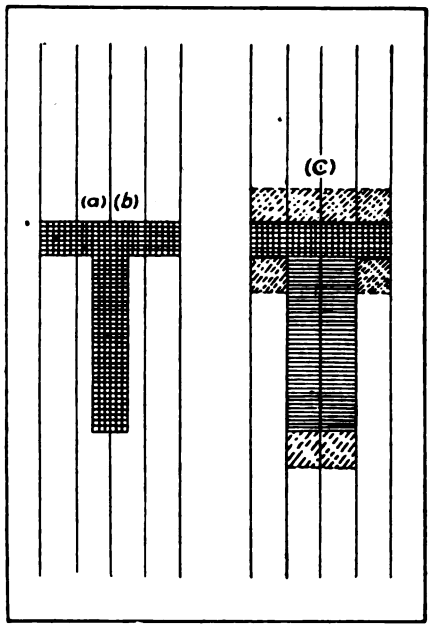

Fig. 6.
Illustrating how distortion or blurring can be caused by the spotlight system of scanning.

Daylight Television.

Briefly, it is done by reversing the spotlight system of scanning. That is to say, the image, object or scene is bathed in brilliant daylight or floodlight, and the perforated disc is interposed between it and a photo-electric cell, and so, as the disc revolves, the subject is still exposed to the cell in a sequence of light strips, and we find that the spot-light principle still holds good.

Finally, it may be a comforting thought to those readers who anticipate buying or building their own televisors to know that the major problems in television progress will have to be solved at the transmitting end, and there is practically no likelihood of early televisors having to be relegated to the scrap-heap after a few months.

The reception of television by wireless, and the actual televisor which reconverts the signal into the image again, will form the subject of a further article by the writer, and it is anticipated that it will be possible to publish with the article a photograph of an image taken from the receiving screen.

THE LIMIT.

Cook (in 1935): "I shall be leaving at the end of the week, ma'am."

Mistress: "Oh, dear, haven't I tried to make you comfortable?"

Cook: "It's your televisor, ma'am; I can't hardly see my young man's face in it."

—*Evening News.*

TELEVISION IN U.S.A.

TELEVISION BROADCAST-BAND.

The Radio Commission has granted the application of WHAS of Louisville, Ky., to engage in television and picture broadcasting on 366 meters between the hours of 1 and 6 a.m., Central Time. The commission also granted this station a construction permit to increase its power from 5,000 to 10,000 watts.

The Proprietors of British Patent No. 200643 are prepared to sell the Patent or to license British Manufacturers to work thereunder. It relates to means for telegraphically reproducing stationary or moving pictures, scenes and the like.

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SOME NOTES ON PHOTO-ELECTRIC CELLS

By COLIN GARSIDE

Readers will remember that Mr. Garside, who is a student member of the Television Society, exhibited a portable televisor of his own construction at the March meeting of the Society, as reported in our April issue. In the following article he gives some interesting information about the heart of a television transmitter, the photo-electric cell.

IN the photo-electric cell, capable of responding to a light flash lasting but a millionth of a second, and sensitive enough to detect the light from stars, we would appear to have an ideal light-sensitive device for television.

The chief difficulty is, of course, to amplify the tiny photo-electric currents, and to get linear amplification up to 20,000 cycles. However, these difficulties appear to have been overrated to some extent, and we can see the former becoming less with the marketing of a new cell which employs strontium, and gives an output of 100 microamperes.

Light Sensitive Elements.

In designing photo-electric cells for, say, colour television work for which, as yet, we have no panchromatic cell, it is essential to know what elements we have to choose from. The following is a list of some of those elements which are definitely light sensitive, or have photo-electric properties.

Element.	*Atomic Weight*	*Element*	*Atomic Weight*
Lithium	6·94	Rubidium	85·4
Sodium	23·0	Strontium	87·6
Potassium	39·1	Caesium	132·8
Zinc	63·37	Barium	137·3
Selenium	79·2	Thallium	204·0

It will be noticed that the elements are arranged in order of their atomic weights, for it has been found (in the case of the alkali metals) that as the atomic weight increases the elements become more sensitive to the longer wavelengths of the spectrum.

The pure metals are not always used in the cell, but are often compounds of the element, such as thallium sulphide, potassium hydride, etc. In passing, it is interesting to note that all those crystals, used as rectifiers in wireless, are light sensitive, i.e. lead sulphide, and a double sulphide of copper and iron.

Colour Sensitivity of Cells.

The emission of cells varies greatly with the metal used and the wavelength of the light, so it is essential to know something about the sensitivity of different metals to different wavelengths. The potassium cell is most sensitive to the blue-violet part of the spectrum, as will be seen from Fig. 1. It is completely insensitive to wavelengths above 4,400 *Au* but can be made almost equally sensitive to red light by special treatment, referred to later. In fact, this process makes the cell almost panchromatic.

Rubidium and sodium are also sensitive in this region, the former being sensitive up to 4,800*Au* and the latter having a maximum sensitivity at about 4,000*Au*. Caesium is more sensitive to yellow light of wavelength about 5,500*Au*. than to any other. Lithium, sodium and potassium are all sensitive to the ultra violet; and thallium, as thallium sulphide, is sensitive to the red end of the spectrum. Summing up, we might arrange metals suitable for colour television schemes as follows:

To collect red light, thallium (sulphide); blue light, potassium or strontium; and green and yellow, caesium or strontium.

Fig. 1 gives the relation between wavelength and emission, in fractions of an ampere per watt of light incident on the cathode. It will be noted that one metal only is almost equally sensitive to all wavelengths. This is caesium, which, it should be noted, gives very little emission as compared with, say, potassium.

A new cell, using potassium on a thin underlying layer of copper, also gives a good approximation, whilst giving a greater output. Our ideal cell, giving linear emission over the whole range of the visible spectrum, should be slightly less responsive to light of longer wavelength to secure the same emission, as the energy carried by, say, red light is, in general, greater than that carried by blue light.

Gas-filled and Vacuum Cells.

Cells using the alkali metals usually operate in an atmosphere of some inert gas, such as argon or neon, the pressure of which varies from ·15mm. to ·75mm.

Cells using a high vacuum prove more reliable and constant in operation, and are preferable in everything except sensitivity and output.

The purpose of the argon or other gas-filling is to magnify the primary photo-electric current, which consists of a stream of electrons emitted from the cathode when light falls upon it. These electrons travel through the gas under the attraction of the positive potential on the anode, ionise the molecules of the gas by collision, and set free other electrons which are added to the primary stream. The amount of this magnification depends on the potential applied to the cell.

For all gas-filled cells the size and form of the cell and electrodes may make a considerable difference to the magnification of the primary electron stream by the gas-filling; but for a vacuum cell the size and form make no difference to the current obtained for a given amount of light.

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It may interest those who attempt to devise new cells that a cell in which the cathode does not form part of the wall is more regular in action.

Emission.

At best, the current obtained from a photo-electric cell when quite strong illumination is falling on the cathode does not amount to more than a few microamperes, and in television work will be much less, because all light falling on the cell must be reflected light. Hence it is important to obtain an idea of the magnitude of the currents which we may expect.

The primary current, or emission, is proportional to the amount of light incident on the cathode, and emission is defined as the ratio of the current obtained to the amount of light. The sensitising process, which cells pass through in the course of their manufacture, consisting of a discharge in the cell through hydrogen, increases the emission very greatly, and the following table (prepared by the General Electric Company) gives one an idea of the currents obtained per lumen of light for a few different cathodes, using as light sources gas-filled lamps and the sun.

Incidentally, it is interesting to note the immense superiority of sunlight over artificial light. The great difference in the currents obtained for sunlight and artificial light is probably due to the larger portion in sunshine of blue light, to which the metals given are chiefly sensitive.

Metal.	*Emission.*	
	Gas-filled Lamp. amp. lumen	Sunlight. amp. lumen
Na ..	$\cdot 2 \times 10^{-6}$	2×10^{-6}
K ..	1·0	6·4
Rb ..	·4	2·1
Cs ..	·15	·4
Kon Cu	·8	1·7

In order that we may get faithful reproductions of an extended scene it is necessary that the response of the cell should be as nearly as possible proportional to the visual effect of the actual scene on the eye, though the colours may vary. We know that the stimulus produced by light falling on the retina of the eye is proportional to the log. of the field of brightness, therefore the response of the cell should be proportional to the log. of the brightness of any particular elementary area of the scene to be transmitted, and strict proportionality of photo-electric response to visual effect will not be obtained unless the emission curve of the cell is the same as the visibility curve.

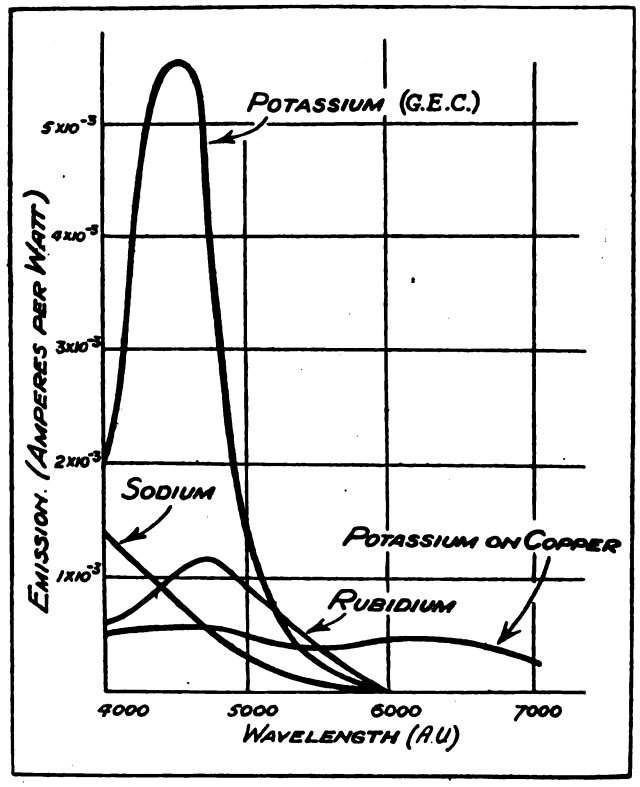

Fig. 1. Sensitivity Curves of alkali metals.

Of the metals now used as cathodes, caesium makes the best approximation, and potassium on copper is not appreciably inferior, while its output is larger and more regular.

Speed of Response.

It is absolutely essential in television that the cell should have no appreciable time lag, otherwise much fine detail is going to be completely lost. In the case of a vacuum cell there is absolutely no measurable time interval between the falling of light on the cathode and the emission of electrons. A lag may possibly be introduced in a gas-filled cell, where ionisation by collision takes place; indeed it is highly probable, but it is so small that it is negligible. What appears to be time lag may arise from the presence of capacity in the photo-cell circuit, or in the cell itself, which capacity the small photo-electric current may take an appreciable time to charge and discharge.

Research.

With the discovery of a cell that responds equally to lights of all colour, instead of having to use several separate cells, we shall be nearer a simple solution of natural reproduction, such as, obviously, we must have ultimately.

Perhaps a compromise could be effected by using a cell having three pairs of electrodes, all with their planes parallel. Light entering the cell would strike the first cathode, consisting of metal gauze, covered with, say, potassium. The electrons emitted would be collected by the corresponding anode. This current would be due to the blue violet radiation.

Then the light would pass through the next gauze cathode covered with, say, caesium or strontium. This electron stream, collected by the corresponding anode, would be due to the yellow-green radiation.

Lastly, the light, after passing through the potassium and caesium covered cathodes would strike an apaque cathode covered with thallium sulphide. The electron stream corresponding to this electrode would be due to the red component of the beam.

The three cathodes would be so disposed relatively that the cathode having the greater emission would be placed where the light had become weakened, i.e. after passing through the two preceding cathodes.

However, it is obvious that there is a large field for research in this direction.

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Obscure Disciples

By CHARLES JONES

MISS PRINCETT stood at her cottage door, blinking furtively at the sky as a bird blinks at a window pane. Schoolmaster and I came upon her as we turned the corner of the village High Street. She did not notice us, for she was gazing at the large moon, which hung like a gilded patera on the lower wall of the sky.

Schoolmaster nudged me—a startling act for a man with whom physical contact was ordinarily difficult. The nudge plainly urged me towards Miss Princett, though there was little enough in common between a faded, star-gazing maid and this gruff, shy man at my side.

The evening air was vital. White points showed on the thorn hedge, each sheathed in a crystal of dew. A fume of spring rose from the new-turned fields, so lately frozen. Such things do soften men and beasts alike, and I can only suppose that the forlorn look of Miss Princett made some appeal to Schoolmaster, amid all the gay circumstance of spring. Anyhow, under the influence of his nudge we drifted together across the lane, only to be arrested in our slow stride by the vehement sound of many strings playing sweet sounds. "The Spring Song," joyous thing that it is, was pouring from some hidden instrument in Miss Princett's cottage.

The Joy of Spring.

I raised my hat, and saw the moving shadow of Schoolmaster's arm as he lifted his.

"Good evening, Miss Princett," I called, "Have you invested in a gramophone?"

Miss Princett caught at her arm in a nervous way she has, and her eyes flickered behind her glasses as she searched our faces.

"Good evening, gentlemen. No! that is not a gramophone. It is—it is my wireless."

"Humph! Interested?" growled Schoolmaster.

"I think I love it beyond anything I have," Miss Princett answered gently. "It is the other half of my conversation. I think I am—interested."

"Sounds good," growled Schoolmaster again. "What sort of set is it? Know anything about it?"

Miss Princett fluttered, with a finger fidgeting at her lower lip, as if in doubt.

A Surprise Invitation.

"A little, Schoolmaster," she answered, and added nervously, "Will you gentlemen come in and take a glass of elderberry wine—and listen for a moment?"

I chuckled as I fell in behind Schoolmaster. Miss Princett of all people! It would be all over the village to-morrow. No man, to my certain knowledge, had ever seen beyond her draped casement, much less passed under the lintel of her cottage door. She was a strange woman, very quiet, of whom it was said that she had strange knowledge. Doctor had made it known that her twisted arms were the result of much agony cheerfully borne. But, beyond a reputation for intelligence and heroic fortitude, no rumour of her was carried in the mazy channels of small-chat which irrigated the conversation of the village.

Within the cottage, Schoolmaster and I stood together as awkwardly as boys at a party. Miss Princett, however, with an access of confidence, showed us chairs and slipped from the room. We sniffed a faint fragrance. The curtains, so drab from without, were tissues of pale blue and grey which suffused into lavender. On a little, bright oak table stood a blue bowl, gleaming, filled with lavender knops threaded with fine silk strings. One grey wall was unbroken, save for the outline of an oaken cabinet containing the wireless set, whereof two carved doors stood open revealing the bronze cone of a speaker. Altogether, it was the room of a lady of exquisite taste.

From the moment Miss Princett returned to us I was but a spectator. She handed wine to us, sweet and odorous, and after a sip and a grimace of satisfaction, Schoolmaster, with head acock, listening, murmured half-reproachfully:

"You have stolen a march on the village, Miss Princett. We did not dream there was such a set here. Why! the set in the Blue Lion parlour isn't in it."

Miss Princett snapped a switch, and plunged us into a silence as vivid as darkness. She turned to Schoolmaster with surprising animation.

"How I should love the companionship of the Blue Lion!" was the astounding reply. "I have often longed to tread down the conventions which make me solitary; to do something desperate to break the loneliness, and it is a wonder that I have not turned up at the Blue Lion long ago. But what can a lorn woman and an invalid do? The broadcast, to me, is the voice of a great friendliness, penetrating monotony—and pain." She hesitated. "I do not know why I am burdening you with such a sorry tale, Schoolmaster."

"Go on! Go on!" he said, gruffly.

"The result is that I may claim to be a student of wireless. When I built this set——"

Covering the World.

"Built it! Good heavens!"

"I determined to cover the world. Listen."

Miss Princett adjusted her dials

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with delicate precision a dozen times, and recited a list of widespread stations as they came in, one after the other.

Schoolmaster, utterly conquered, leaned towards her in an attitude of respect. I believe that on Miss Princett's spectacles there was a mist, though in her eyes there was a sparkle like the gleam of a star. With maidenly discretion she lifted her wineglass and sipped slowly, whilst the mist cleared.

"Miss Princett," began Schoolmaster, in a smoother voice than usual, "there is much wild talk in the village on another subject—Television."

"It is here, Schoolmaster."

Thereafter the conversation was a hum of excitement. It gradually developed into technicalities which, while they engaged my admiration, eluded my understanding altogether. For me, the mystery of humanity overshadows all other things, and I perceived these two, isolated hitherto among the coarser human spirits of the village, as two stars now in joyous collision, spilling a mutual luminousness.

The Thirst for Knowledge.

While they talked on it was urged strongly upon me that the thirst for knowledge, and the interchange of it, is the mechanism of salvation, of understanding, peace, what you will in the name of progress. This enthusiasm for a modern miracle had broken down a barrier between the reticent Schoolmaster and the pain-wracked little spinster. How many such barriers exist between men, classes, nations—to be broken down?

Such fancies do spring up in an idle head. It was well that I was disturbed from these cloudy lucubrations by the strident voice of Schoolmaster, talking more down to my level.

"These boys of mine in the school," he thundered, "give them something to look at and they will learn with a smile. All abstract thinking arises from observation. Education, Miss Princett, begins with pictures."

For the first time Miss Princett seemed overwhelmed, and Schoolmaster, noticing it, continued in a gentler tone.

"Let us look—er—beyond the apparatus, Miss Princett." She smiled, and he reddened as he followed up, hastily, "You—er—have me beaten on the technical side, I admit, but I have a lot of bottled ideas about this. Think what it means! Apart from amusement and the terriffic influence of broadcast beauty, it will eventually put the material of all knowledge on show. It will train the athlete, and release the poor scholar from bondage. It will very nearly give the continents an opportunity to shake hands. Such a thing is the beginning of real understanding, wider sympathy—reform—peace. Speeches and the rest of it, after all, must fall either on ground already tilled, or else on barren soil, but pictures are all things to all men."

"Just what I was thinking," I cut in.

"Oh!" said Schoolmaster, with unnecessary brusqueness. "Of course, Miss Princett, that is looking somewhat ahead. But now that we have service arrangements we shall soon see developments. I wonder if anyone has thought of the multitude of subjects to be got from the microscope? And the telescope? Infinities on view! My hat, we shall have to begin building a television set, Miss Princett."

Miss Princett grew flustered with the most obvious bubblings of pride and the joy of telling.

"I—I have my set ready—in the kitchen there."

"Great heavens! You have? How on earth——?"

"We must talk of it again," said Miss Princett, almost gaily, "I have enjoyed this evening so much. But, gentlemen, I must remind you it is ten o'clock."

"Er—bless my soul—so it is—yes!" said Schoolmaster, his face mantling.

He clutched his hat clumsily and strode to the door, beckoning me.

"Good night, Miss Princett. We'll—come again."

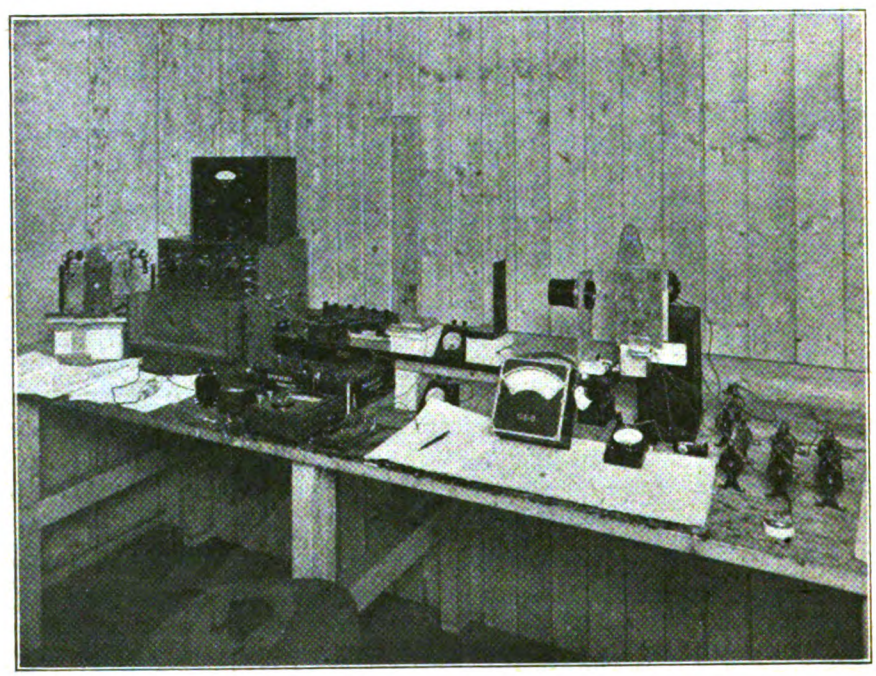
* * *

Outside, Schoolmaster stared a full minute at the round-bodied moon, which had now climbed the sky.

"Shakes!" he burst out, "would you believe it? Did you hear what she told me? A gownswoman! Science!"

After a moment more of contemplation, he demanded, quite fiercely: "When's your next free evening?"

With that question in abeyance he strode off through the village, so that I was hard put to it to keep pace with him.



The last word in light-sensitive devices has still to be said. On this test bench in the Baird Laboratories light-sensitive devices are tested out before being used for experimental purposes.

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How to Consider Power Valves

The question of power valves is one which is of considerable interest to television experimenters, and in the following article some interesting information is given which should prove of value when choosing the type of valve required to fulfil any particular requirements. Some popular misconceptions are also cleared up.

IN most of the well-known ranges of wireless receiving valves are at least two power types, a small power valve and a super-power valve. The fact that different types of power valve are manufactured implies that no one type can be standardised for all reception conditions. In two different valve sets, for example, a super-power valve might be suitable for one and quite unsuitable for the other. As the last valve of the receiver—the power valve—is one of the greatest factors in determining the quality of loud-speaker or television reproduction, its proper choice is of considerable importance.

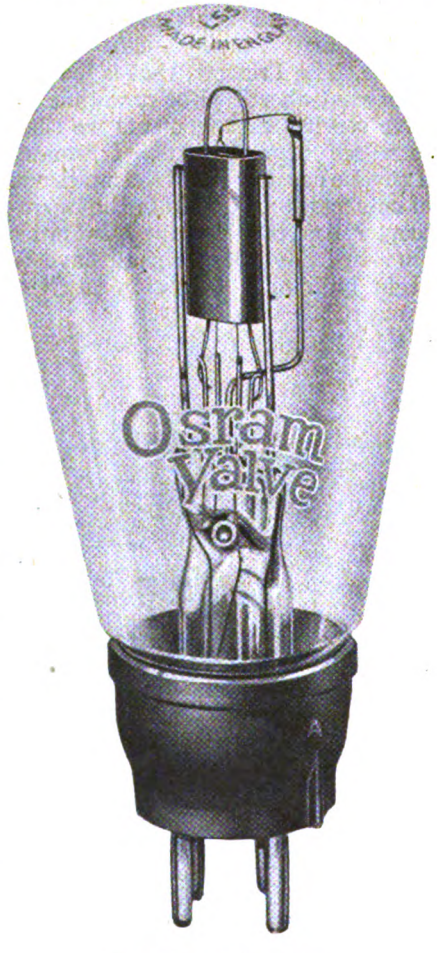
Power Handling Capacity.

The most valuable aid to the choice of a power valve is a knowledge of the power-handling capabilities and power efficiency of the loud speaker itself. Generally speaking, the more sensitive the loud speaker, the smaller the power required to work it at its maximum output. Most loud-speakers are a compromise between maximum sensitivity and maximum evenness of response to audible frequencies. The highest grade loud-speakers, such as the moving-coil type, sometimes sacrifice sensitivity in order to achieve an even response, while the horn loud speaker achieves a high degree of sensitivity by a sacrifice of quality.

Irrespective of type, all loud speakers require power to operate them. This power is supplied by the H.T. battery or battery eliminator. The loud speaker can only operate by virtue of a fluctuation of this power supply. It is the function of the power valve to convert the fluctuating voltages developed in a wireless receiver into corresponding current fluctuations of the source of power. In this sense a power valve does not create power, neither does it amplify to any considerable extent. To wireless-set users this is by no means generally understood.

A Wrong Inference.

A small power valve will convert



The Osram LS5A Valve.

a given fluctuating voltage applied to its grid into a small current fluctuation of the power supply. One might infer that a large power valve would convert the same voltage into a very much larger current fluctuation. The inference would be wrong when applied to ordinary valve construction, because the large power valve, in order to be so classed, must have a low impedance, and this characteristic entails a low amplification factor.

The small power valve can produce small current variations of a power supply; it can, therefore, work a sensitive loud speaker at small volume; it can do this with a comparatively small voltage input. What it cannot do is to produce larger current variations, such as would conceivably be developed by the application of a larger input voltage. It cannot do this owing to two limitations, one being its "grid-swing," and the other its impedance, both characteristics being closely related.

The small power valve has a moderately high impedance, low in comparison with a "general purpose" valve, but still high enough to limit the value of current it will pass through the power supply. The restricted grid-swing follows from the usual construction of the valve, where for a given power output the aim is to secure the greatest amplification.

Grid-swing Explained.

The "grid-swing" of a power valve represents the maximum limit of applied fluctuating voltage that will be distortionlessly interpreted by the valve as fluctuating current. If the applied voltage exceeds the "grid-swing" of the valve, then the valve distorts.

It has been said that some loud speakers, being relatively insensitive, require large current variations to operate them. Another condition where large currents variation are required is when really great volume is involved.

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The small power valve is limited in its use to sensitive loud speakers, or, more generally stated, to average volume requirements, where the current variations are small. With larger power valves the function tends to become more definitely that of a converter of voltage variations into large current variations.

Large power valves have tended to become classed by the size of their "grid-swing." A valve is said to be a good power valve if it has a "grid-swing" of say 60 volts. A power valve could have this "grid-swing" and still not be a really good power valve, because its function is not confined to the handling of the big input voltages required for large volumes; the power valve has to convert this fluctuating voltage input into large current variations of the power supply. The measure of a large power valve's "goodness," or suitability, is its power-producing capabilities. The power valve is the more efficient the smaller the voltage required to produce a given power. From this point of view "grid-swing" is an unsuitable index of a power valve's real worth.

"Index of Efficiency."

A large volume of sound being a first requirement, it is necessary with present-day apparatus to apply large current variations to a suitable loud speaker in order to achieve this. Large current variations can only be obtained with an initially large power supply, controlled by the action of a low-impedance power valve. The corresponding voltage required to produce the large current variations will, obviously, have to be greater than the voltage necessary to work a small power valve at medium volume. The necessary voltage amplification preceding the large power valve will be inversely proportional to the efficiency of the valve, and as we have seen that "grid-swing" is not a true index of efficiency, some more reliable index seems indicated.

The best power valve for any given condition will be the one that has a sufficiently low impedance to pass the requisite output current to work the loud speaker, and which requires the smallest input voltage to do this. In other words, the permissible anode watts dissipation, being a product of the anode volts and anode current, is the most important factor in the choice of a power valve.

Very frequently the power valve is chosen for its voltage-handling capabilities first and its current-passing capabilities second. By this inversion the main object of the power valve tends to be overlooked.

An Example.

An example of the fallaciousness of this method of choosing a power valve will help. An Osram LS5A power valve can handle a voltage swing up to 224 volts, representing a very large signal amplitude. Its

The New Osram LS6A Valve.

anode current, which gives the measure of its power-handling ability, is 33·5 milliamps at 400 volts and 112 volts negative grid-bias.

Looking at the characteristic of another Osram power valve, the LS6A, and classifying it by a "grid-swing" index, it will be seen that at 400 volts the grid-bias is 93 volts, representing a permissible input swing of 186 volts.

At first sight it would seem that the Osram LS6A is not such a big power valve as the Osram LS5A. The reverse is true, because the anode current of the LS6A with 93 volts grid-bias and 400 anode volts is 63 milliamps (25 watts), nearly double that of the LS5A. The Osram LS6A is a much bigger power valve than the Osram LS5A. The former has an amplification factor of 3, the latter 2·5, but although the amplification factors are nearly equal, the impedance of the LS6A is only half that of the LS5A. Its mutual conductance is, therefore, nearly double that of the LS5A.

The Function of a Power Valve.

The conclusions that can therefore be drawn from the above are as follows:—A power valve has one main function, to convert voltage variations into power variations. Its first choice depends on the power requirements of the loud speaker. Its ultimate choice depends on its ability to provide the requisite power, without the necessity for an abnormally high input to do this.

"BRATISLAVA CALLING."

A New Attraction for British Listeners.

Reports of test transmissions of the new Marconi broadcasting station at Bratislava, Czecho-Slovakia, show that this station will provide a fresh source of entertainment and interest for British listeners.

The tests were heard in all parts of the British Isles and both speech and music were generally agreed to be of excellent quality and of good strength.

Comparing the strength of reception from Bratislava with other stations, a number of listeners claim that it is practically as strong as their local stations and well up to the standard of the principal European high-power broadcasting stations.

The Bratislava station comprises a Marconi 12 kilowatt broadcasting transmitter, type P.A.5, employing the principle of low-power modulation. Its wavelength is 277·8 metres (1,080 kh), and among its special features is the half-wavelength aerial, the first of its kind to be used in the broadcast band of wavelengths. The station is connected by land line with up-to-date studios in the centre of Bratislava, Prague, and Brno.

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Invention and Development

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. each.

PHOTO-ELECTRIC CELLS.—*Patent No.* 306996, granted to The General Electric Co., Ltd., and N. R. Campbell. In order to increase the red-sensitivity of a cell, using potassium as the sensitive material, a cathode is formed by depositing on a metal electrode a very thin and *normally invisible* film of photo-sensitive material. Sensitising of the film is carried out in the usual way by the passage of a discharge in hydrogen.

Referring to Fig. 1, a layer (2) of silver is deposited on the wall of a cell. This cell is connected by a tube (6) to an exhaust pump, and also to another tube (7) with a vessel (8) containing potassium. After the cell has been exhausted, baked, and cooled off, the potassium is introduced to the cell chamber by heating the vessel (8) and then sealing off (7). Potassium is next deposited on the electrode (2) by heating the remainder of the cell while the electrode itself is cooled. The electrode is then gently heated until the visible layer of potassium

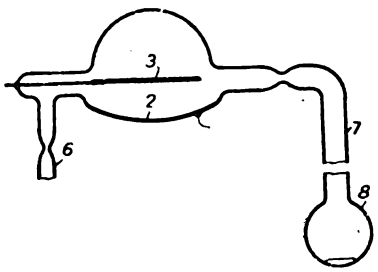
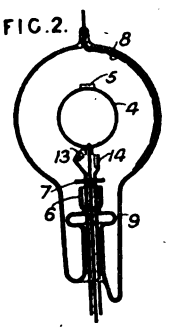


Fig. 1.

rapidly disappears, when hydrogen at a pressure of 1 mm. is introduced. The presence of hydrogen prevents further diffusion of hydrogen.

When the cell is cool, a discharge of a few milliamps is passed for about a minute with the electrode (2) as cathode and a nickel-gauze electrode (3) as anode. The red-sensitivity appears to be determined by the initial condition of the silver coating and probably with the oxygen-containing film on its surface. It may be desirable to admit oxygen just before potassium is introduced or during its introduction. The red-sensitivity of cæsium is not greatly increased by making the film thin.

FIG. 2.



Patent No. 307082. Associated Electrical Industries (Assignees of V. K. Zworykin). (Convention date, U.S.A., March 3rd, 1928.) In the cell described the conducting layer may consist of magnesium, an alkaline earth metal or alloy, aluminium alloy or misch metal. Several light-sensitive films may be deposited so as to form a composite film. The internal structure of the cell is shown in Fig. 2. A piece of magnesium (5) is attached to the electrode (4), preferably of annular form, having a support which carries a glass disc (7) and is passed through a neck having a sleeve (6) and a flange (9). The bulb is first exhausted and sealed, after which the electrode (4) is heated by high-frequency induced current. This action vaporises the magnesium (5), which is then deposited on the wall (8), but the sleeve and flange prevent deposition taking place on the neck of the bulb. One method of introducing the light-sensitive metal is to place a salt of an alkali metal, such as carbonate, cyanide, chromate, borate, phosphate, or tungstate on an auxiliary electrode (14), and then decompose the salt by heating from the filament (13). A filling of gas and a window may be provided for the finished cell.

PICTURE-TELEGRAPHY: SYNCHRONISING.—*Patent No.* 307365, granted to O. Fulton. In a copying-telegraph receiver, in which a revolving drum (supporting the received picture) is brought to rest for synchronising purposes at the conclusion of each revolution, and is then restarted by a signal from the transmitter, an electro-magnetic clutch couples the drum to the drive.

This is shown in Fig. 3, where the gear wheel *D* which drives the drum is connected to the driving spindle *A* by means of a magnetic clutch. When the magnet *M1* is energised by the action of a relay *R* it attracts its armature *B*, which releases a stop *Z* and closes a contact *K*. This last action also closes the circuit of the winding of a magnet *M*, which attracts and holds an armature *An* fixed to the spindle by a tappet *N*.

The driving gear wheel and associated parts therefore begin to rotate, and during rotation the contact *K* is short-circuited through a slip-ring *S2* until, immediately before the completion of a full revolution, a brush *E* reaches an insulating part *I* on the slip ring. The magnetic clutch then disengages, and the apparatus ceases to revolve. The apparatus is locked in the

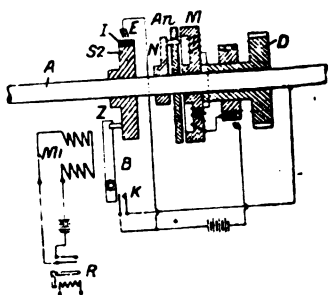


Fig. 3.

position of rest by connecting to the rotatable parts of the apparatus a disc which is provided at one point with a recess into which fits a projection on the armature of an electro-magnet.

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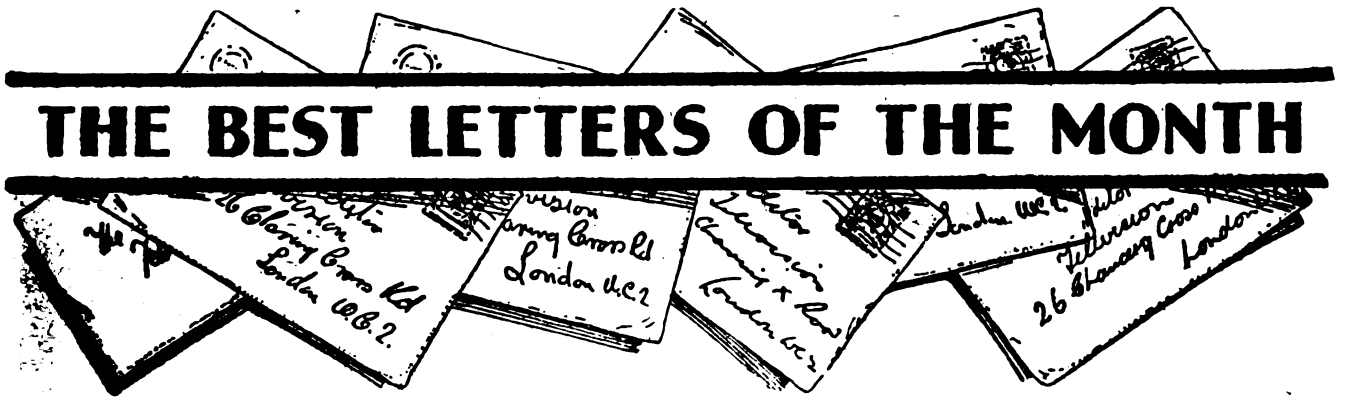
THE BEST LETTERS OF THE MONTH



The Editor does not hold himself responsible for the opinions of his correspondents. Correspondence should be addressed to the Editor, TELEVISION, *26, Charing Cross Road, W.C. 2, and must be accompanied by the writer's name and address.*

QUANTITATIVE ANALYSIS.

May 17th, 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

As a beginner in the field of television I must confess that I was slightly bewildered when I first read Mr. Harries's article on the "Quantitative Analysis of Television." Apparently the theory of optics is being revised by Mr. Harries, and after working out an example I must say I am attracted by the idea of measuring objects from the point of view of their visual effect. This means expressing their dimensions in radians subtended at the view-point. Of course, on second thoughts, we were taught to do this at school in our drawing lessons when we held up a pencil at arm's length to measure scenes in perspective.

To satisfy myself that I had grasped the idea I worked as an example the ideal case, using the author's figures. He tells us that the ideal television screen is to have an area of ·05 radians^2 for comfortable viewing, and that a 1½ inch by 1½ inch picture at 3 feet 10 inches subtends an area of ·00097 radians^2. This means that our ideal screen will be :

$\frac{\cdot 050}{\cdot 00097}$ approximately 50 times the area or 7 times the length and 7 times the breadth.

Further, at a distance of 3 feet 10 inches the width of a scanning line to just merge into the picture is $\beta = \cdot 0007$ radians, which is the figure for 48 lines on 1½ inches, so that assuming we continue to use one disc, as at present, on the small pictures, we shall require an ideal disc of 336 holes on a diameter of 94 feet! This is impossible.

About a year ago I worked out the possible transmission frequency bands for television on the intermittent or dot principle, and I became very pessimistic. The calculations for the ideal system as outlined above made me more so, and I felt rather depressed about the whole business until I was fortunate enough to witness a demonstration at Long Acre Since then my enthusiasm has increased, and I have read Mr. Harries's article a dozen times and found it most helpful in the design of a television receiver.

This leads to the suggestion that we could well do with some figures on the picture modulation of the transmissions which will shortly radiate from the B.B.C., since it will be necessary to know the number of strips to the breadth of the picture before we can receive it satisfactorily.

I am, Sir,
Yours faithfully,
THOMAS M. C. LANCE.

BEACH COTTAGE,
BOTLEY ROAD, HEDGE END,
BOTLEY, HANTS.
May 1st, 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

I read with interest the paper, "A Quantitative Analysis of Television." I would like to point out that each person "looking-in" has a different acuity from that of his neighbours, so that a perfect picture cannot be realised; the problem being to build up one of a size which, while it does not suit all eyes, tends to compromise between the many different types of vision.

I am, Sir,
Yours faithfully,
W. H. HEBDIGE.

48, RECTORY ROAD,
LONDON, N.16.
April 5th, 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

I was very interested in the paper by Mr. J. Harries, A.M.I.R.E., published in the current issue, and would like to raise the following points :—

1. *Re* "Comfortable Vision." I think that the "seers" would automatically adjust themselves to the appropriate distances, i.e. the larger the screen the further they will go from it, this, of course, depending upon the sights of the "seers." At the same time I think that on any screen or stage we usually find one main incident and not a number on various parts of the stage. My meaning will be clearer if the reader has been to a football match and noticed the whole crowd ("seers") sway as it follows the ball and players.

2. I notice that Mr. Harries refers to transmission of pictures all through his paper, and this is not really television, as in the latter case the object being transmitted is in three dimensions, not two as in a picture. I would like to know if the results are the same.

3. Although he does not give much definition between transmission and reception, I think that he has confused them throughout the paper. He does not say whether the formulæ hold good for both.

Trusting that the above will be of interest,

I am, Sir,
Yours faithfully,
S. GOLDSTEIN.

A NEW THEORY FOR SELENIUM.

GRENEHURST PARK,
CAPEL, SURREY.
May 1st, 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

It was Mr. Shearcroft's article on "Ionisation" that prompted me to write this letter, and to put forward to you what I believe to be so far the most satisfactory theory on selenium photo-activity, which hypothesis has not so far been put forward in your columns.

It is well known that the conductivity of electricity in metals depends upon the flow of free electrons present in the metal. What little electrical conductivity selenium possesses is due to the presence of free electrons.

The silent electric discharge, radio-active substances and light have the power of ionising a gas. That is to say, atoms can be bereft of electrons, leaving them positively changed or ionised.

The action of light on a selenium atom is to split off an electron, thus leaving it ionised. There are now more free electrons

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present in the selenium, so that its electrical conductivity is increased and therefore its resistance falls.

But were this the only process at work all the atoms would soon be ionised, and selenium would become as good a conductor as silver or copper.

We have already seen that on ionisation there are present in the selenium atoms, ions and electrons. Ions being positively changed attract the electrons, so that recombination takes place. The whole process consists of a dynamic equilibrium in which atoms are continually losing and gaining electrons.

This then explains the fact that selenium is never completely ionised. The greater the ionisation the greater the number of free electrons present, and consequently the greater the chances of reunion with an ion taking place. Hence at saturation an equilibrium will exist between atoms, ions and electrons, whereas many atoms become ionised as ions gain electrons.

The theory explains the selenium lag satisfactorily. Supposing that, consequent to the action of light, there is produced a certain number of free electrons. On cutting off the light source, each of these electrons has to unite with an ion, and the greater the number of electrons, the greater are the chances of combination to form an inertatom. Hence, to begin with, ions and electrons will be paired off fairly quickly; but as the process goes on the electrons will have further to travel before encountering an ion, so that recombination will steadily become slower and slower. The final electrons will take an appreciable time to pair off with the few remaining ions, so that it seems probable that the greater part of the lag is due to the final recombination.

According to this hypothesis it seems likely that were one to work at a definite ionisation when experimenting with selenium, one ought to reduce the lag considerably. Has anyone tried the experiment?

I am, Sir,

Yours faithfully,

C. M. ADCOCK.

ELECTRO-MAGNETIC WAVES.

69, KNELLER ROAD,
WHITTON, TWICKENHAM,
MIDDLESEX.
May 1st, 1929.

THE EDITOR,
"TELEVISION,"

DEAR SIR,

Your correspondent, A. Haywood, whose letter was published in the May issue of your journal, has, I venture to think, a wrong conception of the nature of lines of magnetic force.

He assumes that a line of force is too much like a rope which can be jerked about by the electron to which it is attached.

Now, I would point out that lines of magnetic force are, in themselves, merely indications of polarisations existing in the ether (or so Hertze would have us believe). Another way of saying the same thing is that the lines of force indicate the state of strain of the ether. But, in the case in question, a wave motion is only a periodic change of state of strain of the ether, i.e. a *moving magnetic field* (or perhaps, more correctly, a moving electro-magnetic field). To say that the dynamic field (the waves) is transmitted by the static field (static with relation to the electron) is clearly inadmissible. It is like saying that the *folds* in a curtain transmit the *ripples* caused by a draught. Either can exist without the other, the curtain being the necessary medium for transmission, and in the analogy the curtain stands for the ether.

Moreover, in the last paragraph of his letter Mr. Haywood contradicts himself in trying to explain away "action at a distance" by means of "planetary fields of force." This is quite impossible, as the one idea goes hand in hand with the other. The idea of interplanetary fields of force, varying according to the law of inverse squares, originated with Newton, and these fields were finally proved to have no real existence by Einstein in his theory of general relativity.

As Bertrand Russell says, in his "A.B.C. of the Atom,"—"Newton's action at a distance, which was always considered something of a scandal, was explained away by Einstein's theory of gravitation."

Wishing your paper the best of luck.

I am, Sir,

Yours faithfully,

DENNIS J. MYNALL.

The following two letters, addressed to the Editor of the *Wireless World*, appeared in the April 24th and May 8th issues of that journal. We reproduce them here for the information of our readers.

TELEVISION.

SIR,

In your correspondence columns of April 3rd, Dr. Tierney states that he has "witnessed the image of a boxing match received with remarkable fidelity put over on the ordinary commercial televisor." Will not Dr. Tierney, as Chairman of the Television Society, discuss a few of the facts and figures relating to such an achievement and consider the technicalities of the apparatus. Such information would be welcomed by readers of a technical journal.

He draws a comparison between the relative educational potentialities of photo-telegraphy and television. Surely he is looking a long way ahead. It is like building the top story of a house before the the foundations are put in.

Most important is Dr. Tierney's last paragraph in which he recommends the amateur to throw in his support to further the progress of television. It is not "lack of appreciation," but rather lack of information that sets up a barrier in the way of amateur activity. It is extraordinary that so far the amateur has made no claims in the field of television; yet here is a subject, simple in its present form and not beset with obscure mathematical considerations so essential to a study of radio.

Before the time arrives when the B.B.C. will conduct television transmissions, may I suggest that full details be disclosed as to mechanical standards to be adopted, in the same way that information has been given out by the B.B.C. in regard to the standards set up for picture broadcasting. We shall want to know the extent of analysis of the picture and the ration of rate of traverse to dimensions and any other special signals or intervals that may be thrown in as an aid to synchronising. Manufacturers also will need these details.

Television receivers are customarily provided with very generous amplifiers (L.S.5A valves with 350 volts), yet Mr. Baird states in a press interview published in the London *Evening News* that the apparatus can be sold at about £12. Apparently he has something more sensitive than a flashing neon lamp for forming the image.

Listeners may have heard the broadcast talk on television given recently from 2LO and probably S.B. to other stations. In view of the nature of that broadcast the B.B.C. can no longer pretend that they are unsympathetic towards the forthcoming tests. F. HALSEY.

SIR,

I welcome the courtesy of your columns to reply to your correspondent's letter in your issue of April 24th, in which Mr. Halsey asks, quite rightly I think, for fuller information and more constructive articles on the subject of television, and I may say at once that it would be an easy and pleasant matter to press for the immediate release to the technical journals of a number of constructive articles were it not for the two fundamental difficulties that have hitherto delayed this new development. I refer, of course, to broadcasting facilities and to the patent situation. I am happy, however, to observe that in both these problems matters are now approaching an equitable solution, and it is the earnest desire of all concerned that these services shall now be delayed no longer than is essential to effect the necessary arrangements. Meanwhile, your correspondent will readily recognise that it would be of little use constructing a receiving apparatus in the absence of the all-important transmitting service, and it is now confidently anticipated that as a result of co-operation and goodwill this essential service will soon be readily available to the public and to the amateur experimenter alike.

But I am sure Mr. Halsey will allow me to say that the study of television is by no means dissociated from obscure mathematical consideration as he appears to suggest, nor indeed are the problems unrelated to those of radio. On the contrary I need only mention one of the difficulties that preceded the recent official broadcast tests, viz., the problem of sideband interference, which, as a result of patient study and experiment, has now been almost completely eliminated.

I must, however, add a word of praise to the amateur activity to which your correspondent refers. The development and demonstration of true television, like radio telephony, was in its inception due entirely to the amateur, and it is for this reason that we have pleaded so long and so earnestly for a fairer recognition and less fettered facilities for the amateur experimenter to whom our modern civilisation owes so much and is so loath to acknowledge. CLARENCE TIERNEY

The Television Society,

April 25th, 1929.

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ermany First to Broadcast Baird Television Daily

6D MONTHLY

Television

The Official Organ of the Television Society

VOL. 2 JULY 1929 No. 17

THE POWER BEHIND GERMAN BROADCASTING

Secretary of State, Dr. ing. Hans Bredow, who, on behalf of the German Post Office, controls the broadcasting situation in Germany. (See Sydney A. Moseley's article on page 244.)

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THE TELEVISION SOCIETY

The Television Society was founded on September 7th, 1927.

The Society makes its appeal to those who desire to share in the responsibility of furthering this new branch of applied science.

THE OBJECTS OF THE SOCIETY

may be summarised as follows:

(*a*) The Study of Television and its application in applied science and industry.

(*b*) To afford a common meeting ground for professional and other workers interested in current research relating to Television and allied subjects and to afford facilities for the publication of reports and matters of interest to Members.

(*c*) To encourage the formation of *Local Centres* of the Society in the Provinces, so that by social intercourse and discussion among members these aims may be more fully realised.

The present register indicates a world-wide membership.

ORGANISATION.

The Society consists of one Honorary Fellow, Fellows and Associates, and the management is vested in a Council of Fellows, including the President, three Vice-Presidents, and Ordinary Fellows.

FELLOWS.—Ordinary Fellows must be elected by the Council. Candidates for the Fellowship must be proposed by two Ordinary Fellows, the first proposer certifying his personal knowledge of the candidate.

ASSOCIATES.—Any person over 21 interested in Television may be eligible for the Associateship without technical qualifications, but must give some evidence of interest in the subject as shall satisfy the Committee.

STUDENT MEMBERS.—The Council have arranged for the entrance of persons under the age of 21 as Student Members.

SUBSCRIPTIONS.—The annual subscription for Ordinary Fellows is 20s., with an entrance fee of 10s. 6d.; and for Associates 10s., with an entrance fee of 5s.
The annual subscription for Student Members is 5s., entrance fee 2s. 6d.

LIFE MEMBERS.—Life Membership may be secured at a fee of £10 10s.

MEETINGS.—The ordinary meetings of the Society are held in London at the Engineers' Club, Coventry Street, W.1, at 8 p.m., on the first Tuesday of the month (October to May inclusive). Notices of meetings are posted to all members about seven days before the meeting.

Full-size reproduction of the new Television Society Badge, which is available to accredited Members, and may be obtained from the Head Office, price 1s.

The official organ of the Society is "Television," published monthly by the Television Press, Ltd., 26, Charing Cross Road, W.C.2.

A memorandum for the guidance of members wishing to form a Local Centre of the Society may be obtained (gratis) on application to the Joint Hon. Secretaries, 4, Duke Street, Adelphi, W.C. 2.

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THE WORLD'S FIRST TELEVISION JOURNAL

Vol. II JULY, 1929 No. 17

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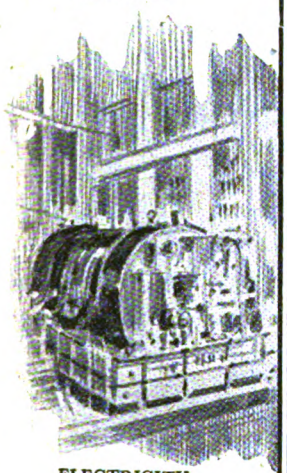

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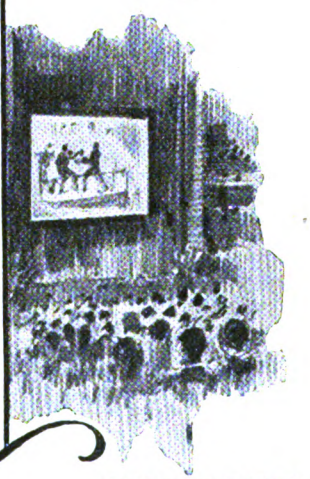
OPTICS



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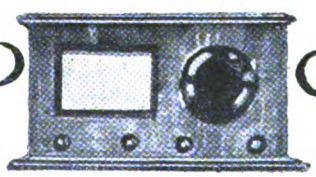

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Television

THE WORLD'S FIRST TELEVISION JOURNAL

The Official Organ of The Television Society

Edited by A. DINSDALE, A.M.I.R.E.

Consultants: Dr. C. TIERNEY, D.Sc., F.R.M.S.; W. J. JARRARD, B.Sc. (1st Hons. Lond.), A.R.C.S., A.I.C.

Technical Editor: J. C. RENNIE, B.Sc., A.M.I.E.E.

Vol. II] JULY 1929 [No. 17

EDITORIAL

IN our last issue we gave our readers the latest available information concerning television developments in Germany, which was to the effect that the Baird Company's representatives had been very cordially received by the German Government, before whom some very successful demonstrations had been given.

* * *

ELSEWHERE in this issue we give further information about the situation in Germany, from which it will be seen that events have moved with commendable rapidity. Since Mr. Moseley's article was written the daily press of this country has recorded the fact that negotiations between the Baird Company and German interests have successfully culminated in the formation of a powerful German company.

* * *

IMMEDIATELY the German Government became convinced of the great superiority over other systems of the Baird system of television, Captain Hutchinson, the Managing Director of the Baird Company got in touch (with the cordial assistance of Dr. Loewe) with three well-known firms which he believed should co-operate in the development of the Baird system in Germany. These three firms are Bosch, Loewe Radio, and Zeiss. The first of these, famous for magnetos, would appear admirably suited to develop electric motors for driving television scanning discs. The second firm, which specialises in multiple valves, may be expected to devote itself to the wireless and amplifier sections of television work, while great developments on the optical side may be expected from the Zeiss Company.

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* * *

THE name of the new company is Fernseh, A.G., with headquarters at the Zeiss works in Berlin. It will, it is understood, devote itself to effecting improvements in the apparatus, and to manufacturing and distributing Baird televisor receivers for the German market. With three such important firms directing their attention to the subject, many important improvements may soon be expected.

* * *

MEANWHILE, television transmissions are being broadcast daily from Witzleben, Berlin, and have been very successfully re-

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ceived at the Baird Company's laboratories in north London. It is understood that television transmissions will very shortly be broadcast from Koenigswusterhausen, a much higher powered and longer wave station, which can easily be picked up anywhere in the British Isles.

* * *

Germany First.

THUS Germany, enterprising and go-ahead, has established a lead over this country, and snatched from us the honour of being the first country in Europe to broadcast television regularly. This is a bitter pill for the country which produced the genius who translated the long-contemplated dream of television into a practical reality.

* * *

THERE is a striking contrast, too, between the attitude of the Runafunk Gesellschaft (the German B.C.C.) and that of the B.B.C. when representations were first made to them to broadcast television. The distinctive factors are that the Baird people went to Germany *at the express invitation of the German Government*, and that broadcast transmissions were made, and are still being made, at no cost to the Baird Company.

* * *

Hastings pays Tribute.

PROPHETS proverbially have no honour in their own country, and outstanding men of genius seldom receive due recognition until either they are too old and embittered to appreciate it, or have long been dead and buried. It is refreshing news, therefore, that the town of Hastings has decided to put up a tablet to Mr. John L. Baird on the walls of the house at No. 8, Queen's Arcade. It was to that address that Mr. Baird retired in 1921 after a serious breakdown in health following his activities in various lines of business not even remotely connected with television.

* * *

IT was during this enforced retirement that Mr. Baird's mind once more began to occupy itself with the problem of television. He had contemplated it for many years previously, and made certain experiments, but it was not until he went to Hastings that he tackled the problem really seriously and with the determination to solve it. When he returned to London in 1924 Mr. Baird had broken the back of his task, and was not long in achieving complete success.

* * *

Helensburgh Next?

NOW that Hastings has led the way, may we expect further interesting developments from Helensburgh, the town at the mouth of the Clyde, where the inventor first saw the light of day?

* * *

The British Association Meeting.

LAST year the annual meeting of the British Association was held in the imposing precincts of the University of Glasgow. Members of the Association who attended the meeting had the opportunity of witnessing demonstrations of Mr. Baird's latest scientific achievements, stereoscopic television, and television in colours.

* * *

THIS year the meeting is being held in South Africa, at Cape Town and Johannesburg, and in response to the invitation of the South African Committee of the B.A., the Baird system of television will be demonstrated in both cities to the visiting scientists. A delegation, headed by Lord Angus Kennedy, Vice-President of the Television Society, will have charge of the demonstrations. By the time this issue reaches our readers, this delegation, together with a large number of British scientists who are attending the meeting, including Dr. Tierney, Chairman of the Society, will have sailed for South Africa on the *Llandovery Castle*.

* * *

A Correction.

OUR attention has been called to the fact that in our Editorial last month, and in the heading of Sir Ambrose Fleming's article entitled "Comparative Tests of Television Apparatus," we stated that Sir Ambrose pointed out errors in Mr. J. H. Owen Harries' thesis on "A Quantitative Analysis of Television," which appeared in our May issue. On closer examination of Sir Ambrose's article we find that these remarks are not justified by the facts, and we therefore have pleasure in withdrawing them and correcting the false impression which we created. Sir Ambrose's actual wording is quoted in a footnote to another article by Mr. Harries which appears elsewhere in this issue.

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SOME NOTES ON SCANNING

By RONALD R. POOLE, B.Sc., *Fellow of Television Society*

At the May Meeting of the Television Society, Mr. Poole gave a very interesting talk, illustrated by most convincing experiments, on the subject of image scanning. In the following article he elaborates his theme.

THE general principles of scanning are well known, but the details of operation and the disposition of the various parts appear to be less generally understood, and with the object of demonstrating these points to a small gathering of the Engineering Society of University College, London, a rough apparatus was constructed. This apparatus, with one or two additions and alterations, was shown at the May meeting of the Television Society.

Apparatus Used.

It consists essentially of a motor-driven disc with interchangeable systems of holes, by means of which a brightly illuminated lantern slide is explored, and the image, or succession of images, projected upon a screen. The arrangement of the model is shown in Fig. 1. The slide *S* is illuminated by an intense beam from the lantern *L*. The disc *D*, in which a series of holes is drilled, rotates close in front of the slide, at a speed which can be varied from zero to about 3,000 r.p.m. by a rheostat in series with the motor.

A direct-reading speed meter *T* is mounted on the motor spindle. A lantern projection lens combination *P* receives light through the scanning holes, and focuses it on the screen *A*, which is of squared tracing paper. Adjustment is provided so that a sharp focus may be made on the screen of either the surface of the slide or the edges of the scanning holes. The purpose of this adjustment will be explained later.

Using the former focus, there appears on the screen a small part of the view of the slide, bounded by the slightly blurred edge of the hole. As in the Baird system, the disc is perforated with holes disposed in a uniform spiral, such that the radial pitch is equal to the width of the hole, which in this case is round.

It is clear, therefore, that if the disc is rotated slowly we will see on the screen the spot of light describing a series of curved paths, each one showing a narrow strip of the picture viewed continuously from top to bottom. Successive strips are, or should be, exactly contiguous, so that no portion of the picture is unexplored.

In the model shown only 16 holes are used, a diameter of $\frac{1}{8}$ inch being chosen. Consequently, a picture 2 inches wide could be explored, and a height of about 2 inches is taken. This height is limited mainly by the curvature of the path of the holes, which in this case has an outer radius of $6\frac{1}{2}$ inches. Fig. 2 indicates this limitation and shows the way in which the picture is divided up.

If now the disc is rotated at a speed of, say, 16 revolutions per second, the picture will be completely traversed an equal number of times a second, and will appear more or less free from flicker, since each point is momentarily illuminated once every one-sixteenth of a second; and persistence of vision lasts somewhat more than this time, even for weak or very short illuminations.

On setting the disc in rotation, the strips, at first apparently disconnected and only one at a time, are seen to succeed each other with increasing speed, until finally the picture grows clear and steady, showing only faint lines across it where the holes either overlap or do not quite meet.

Application to Practical "Televisors."

Let us now consider the application of this principle to a television transmitter. Fig. 3 shows the essence of the model stripped of all lenses so

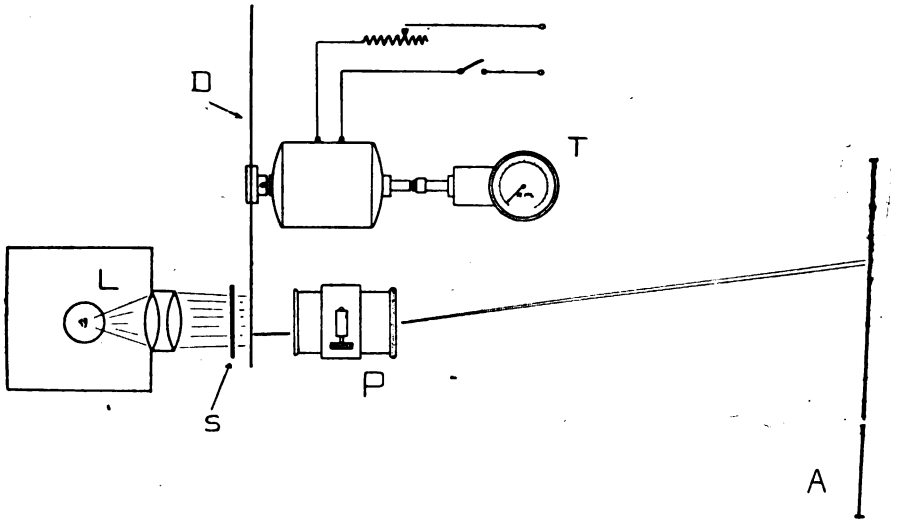

Fig. 1.
Showing the general arrangement of the apparatus. L is the projector lamp, S the slide to be explored, D the disc, P the projection lenses, and A the screen.

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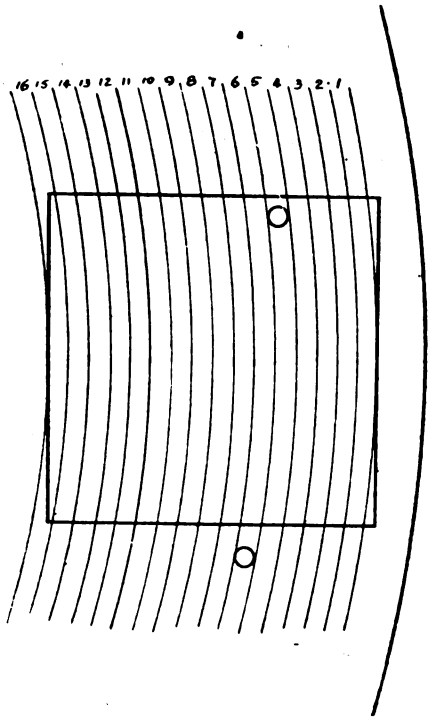

Fig. 2.
This represents a portion of the disc. The concentric arcs show the paths of the holes across the field of view which is bounded by the square. A small part of this square is seen to be cut off, due to the curvature of the strips.

that the light rays all travel in direct lines. The light, starting from the point source *L*, throws simply a shadow of the slide *S* on to the screen *A*. The perforated disc *D* explores the slide strip by strip and the final result is much as before, the lenses only being included to obtain stronger illumination and sharper definition.

If we substitute for the screen *A* a well-illuminated picture of the same size, take away the slide and put a photo-electric cell in place of the light source *L*, we have the essentials of a transmitter. All optical phenomena are perfectly reversible, and therefore light from points on the picture will pass through the holes in the disc, only the light from one particular point falling on the photo-electric cell at a time. Thus the picture will be scanned or explored, successive strips of it being, as it were, shown to the cell from end to end.

The receiver is a similar device, in which an identical disc is driven synchronously with that of the transmitter, and some form of lamp placed in the position corresponding to that of the light-sensitive cell. The brilliance of this lamp is made to vary with the photo-electric currents, and hence with the varying light and shade of the subject.

The light from this lamp, being projected on to the receiving screen, will correspond in intensity and location to that from the original picture, or subject, which will thereby be reproduced with a detail, or lack of it, depending on the nature of the scanning holes, and the design of the amplifiers and intermediate apparatus.

Transmission of Detail.

With regard to the transmission of detail, and the sharpness of definition, about which some sense and much nonsense has been written, some ideas may be gleaned from an examination of one of the strips or bands projected on the screen by the model. Let the lens be focused so that a sharp image of the hole is projected on the screen. Then the circular spot is found to have an almost uniform intensity of illumination corresponding to the average density of the particular tiny spot of the slide under view, and while the spot is stationary all detail smaller than itself is lost.

If the disc is moved the slightest amount, the average density will be altered, since a new detail with a different light value will come in on one side of the hole, while an old one passes out the other, and this variation will be of a continuous nature. So, then, if we plot a graph of average illumination of the hole against distance along the strip, we will get a continuous curve whose changing contours will be a measure of the changing details. The amplitude of the curve at any point measures the intensity of the light at the corresponding point in the strip, and the slope represents the rate of change in intensity, which is a measure of the fineness of detail or definition.

If the hole is large compared with the details it is to reproduce the sudden introduction of a small detail will not greatly affect the average illumination over the hole, and the response of the cell to this change will be correspondingly small. Hence the steepness of the curve under this condition will be reduced. Conversely small holes will generally give better reproduction.

Mr. Owen Harries has recently given us a valuable starting-point on which to base a quantitative treatment of this subject, and a good deal of mathematical work of fundamental importance has been done both in this country and America, with a view to determining optimum scanning speeds and sizes of holes.

From a purely qualitative point of view, however, if practical considerations limit the number of holes in the disc, it would appear that the best shape would be a slit with its greatest length along a radius. This

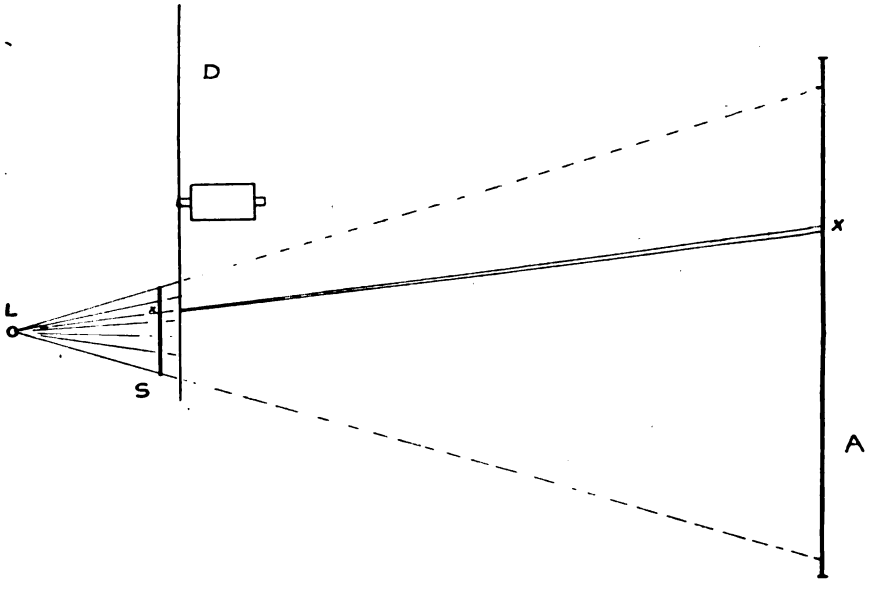

Fig. 3.
Skeleton arrangement of the model used as a shadowgraph.

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shape would result in greater variations in the average illumination over its area for small changes in picture density along its path.

Side Band.

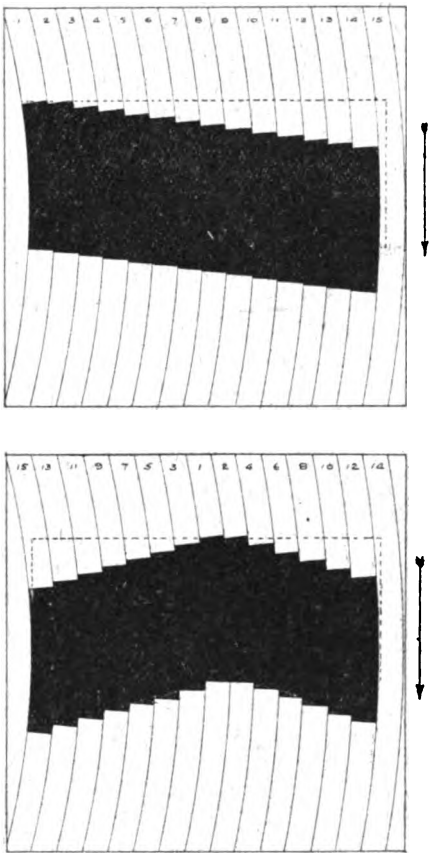
If the curve of light intensity against distance along the strip is analysed into its complete Fourier series of sine waves, it will be found to consist of an almost infinite number of components starting with very low frequencies, and running up to exceedingly high ones. The arrangements and amplitudes of these will, of course, be constantly changing in different parts of the curve.

It is evident that for rapidly changing detail the curve will be peaky or jagged, and this represents proportionately greater amplitudes among the higher frequency harmonics. It may so occur that a considerable part of the average height of the curve is due to frequencies of an order outside the range which it is desirable to transmit. That is to say, definition finer than a certain degree gives rise to these high harmonics, and we are therefore obliged to sacrifice this fineness of definition, not because it cannot be followed and reproduced, but because it is not worth the extra complication to our amplifiers and the extra width of side band, the latter being taken to mean the maximum frequency superimposed on the carrier wave.

It should be borne in mind that fineness of definition, in this connection, depends not so much on the actual size of small details, but on the abruptness of their contrasts. Thus it would be more difficult to reproduce with absolute fidelity a fine pen-and-ink drawing than a fairly soft photograph, though the latter might well be more detailed; and a vividly contrasting scene in a strong light would, in practice, lose much of its hardness, since the very high frequencies on which the contrasts depend, must be sacrificed at any rate while transmission takes place on comparatively low frequency carrier waves.

If television transmission were made on, say, 10 metres with a 1 per cent. side band, we would then have available modulation frequencies up to 300,000, as against the 20,000 or so imposed by present limitations.

If we are to limit our side band to this latter frequency, we have two ways of cutting off the surplus harmonics. The more obvious one is by electrical filtering; and this is more or less arranged for us by the fact that most amplifiers will pass very little above 10,000 cycles per second. The other way is by enlarging the scanning holes, or slits, so that the rates of change of light



Figs. 4a and 4b.

Illustrating the distortion of a rectangle when moved in the direction of the arrows at the sides. The height of each step, measured between the mid points of each strip, is the distance moved in the time interval between adjacent strips, which, in 4a is 1 250th second, and in 4b 2 250th second. Notice that the ends of the strips are square, i.e., radial to the disc. The figures along the top refer to the order of viewing of the strips.

intensity become lower. This second method should always be adopted in conjunction with the first, since the larger the aperture the more light falls on the photo-electric pick-up, with consequent gain in efficiency.

The optimum size and shape of hole has been calculated for various conditions of operation, but for general experimental purposes a square one appears to give the best results, the size depending on the tangential speed (speed of traversing). A few experiments with the model disc indicate that a traversing speed of about 6,000 × (circumferential width of hole) per second, is a good practical figure, giving fair definition with a top frequency of 10,000 cycles per second.

This means that with a disc of mean radius of 6 inches, and the disc revolving at the minimum speed of 10 r.p.s., the holes should be 0·06 inch square. If a square picture is required, this would give 24 holes, and the field would be 1½ inches square.

The above figures are entirely empirical, and are by no means ideal, but they give a workable arrangement for experimenting.

Linear Distortion of Moving Pictures.

The accurate reproduction of objects in rapid motion presents certain difficulties both in television and in cinematography. In the latter, the main trouble arises from the fact that if an object moves more than a certain amount between successive exposures, a pronounced jerkiness of motion or flicker becomes apparent. It is estimated that this flicker is seen if the movement per exposure subtends at the observer's eye an angle greater than about 0·01 radian, and for perfect continuity of apparent movement this angular movement must be reduced to about 0·003 radian per exposure.

In television we have not only this difficulty to contend with, but the further fact that the movement is not made by the object as a whole but is seen progressively from strip to strip, so that portions of the object in successive strips undergo a slight displacement relative to each other. If the movement is in the direction of the length of the strip, this displacement will result in a cornerwise distortion as shown in Fig. 4A. If the motion is across the strips, the effect will be less noticeable, resulting only in a slight breadthwise distortion, a widening or narrowing of the object. For this reason, it is better to employ vertical scanning in preference to horizontal, since in an ordinary moving scene the greater part of the motion is from side to side, and there is rarely much up and down movement.

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The effect of this distortion is shown very clearly in the model, by moving a small object, a key or a screwdriver, behind the spinning disc, and observing its shadow on the screen. In some cases the vertical displacement between adjacent strips amounted to more than the width of the object itself.

A fundamental cure for these troubles in either television or cinematography is to speed up the rate of viewing, so that the movement between successive strips or exposures is imperceptible. This is exemplified in the latter art by the use of the ultra-rapid camera, or "slow motion," but the application of this principle to television would put a further strain on that already tender point, the side band.

Some Experiments with the Model.

Mr. Cameron Rennie, in his very interesting and suggestive paper to the Television Society in April, asked the question: Would the same visual impression be obtained if the picture were examined in non-consecutive strips? For instance, referring back to Fig. 2, what would be the result of viewing the strips in the order 1, 16, 2, 15, 3, 14, etc., instead of 1, 2, 3, 4, etc.?

To test this the disc with the simple spiral set of holes was replaced by a double disc in which one plate could be rotated slightly relative to the other, so as to cover or uncover various sets of holes. Three sets of 16 holes were drilled, the first in a simple spiral, the second in the order mentioned above, and the third in an entirely haphazard order, taking care only that each hole covered a different strip. The three arrangements are sketched in Fig. 5.

On starting up the disc from rest, with the second set of holes uncovered, a rather confusing array of disconnected strips is first presented, and owing to the absence of continuity of view, it is difficult to get any idea of the nature of the whole picture. As the speed increases, however, the effect approximates to that of the uniform spiral; each half consisting of an opposite spiral of double the circumferential pitch and a radial pitch equal to the diameter of one hole.

Hence, so long as the time of scanning is less than that of visual persistence, continuity will be as good as that obtained by the ordinary method. Experiment shows that the results of the two systems are indistinguishable from each other as far as still pictures are concerned. The only difference lies in the fact that the band displacement due to movement in the direction of the scanning lines is now modified, the greatest displacement being in those strips viewed last, i.e., in the centre, the outside strips being viewed almost simultaneously. The total displacement at the centre will be the same as that between opposite sides in the former case, and as may be seen from a comparison of Figs. 4A and 4B there is little to choose between the two systems on this account.

The effect of the third set of holes could be inferred from the foregoing experiment, and is found to give perfectly good reproduction when run at the normal 16 traversals per second. The displacement of the bands is, of course, quite irregular, and in some cases this may be rather troublesome, since adjacent bands may be widely separated in time, and so undergo a large relative movement. The actual value of this movement is clearly the product of the speed of the object and the time interval between the successive strip exposures.

Secrecy of Transmission.

One of the more or less unconsidered possibilities of television is the transmission of cinema film to be re-recorded and subsequently shown in the ordinary way, the radio channel being used only for speed of transport (and incidentally to complicate the task of the Customs collectors). This applies principally to news films from other countries, and it is evident that secrecy of transmission is essential, in view of the keen competition in this line. With a fair choice in the number of scanning lines, and the enormous number of possible arrangements in the order of such lines, eavesdropping is almost impossible.

Exactly the same argument applies to ordinary transmission of news items, such as sports or weddings or accidents, for simultaneous showing in the television theatres of the future. Rival news suppliers will require mutual protection against eavesdropping, which will provide ample incentive to the development of automatic disc-changing devices and other aids to exclusive presentation.

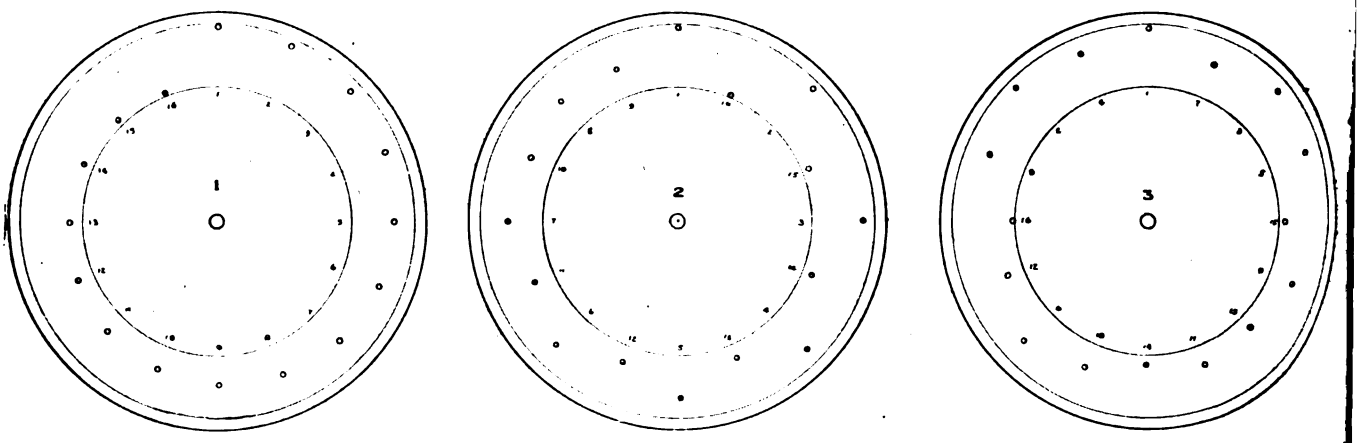

Fig. 5.
The three different sets of holes used in the experiment.

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The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

Part VII.—THE BIRTH OF WIRELESS.

IN 1811, the German scientist, S. T. Sommering, whom we have already mentioned as one of the great pioneers of line telegraphy, used water instead of wires to conduct an electric current for telegraphic purposes. This was the first time that a practical method was employed for sending telegraph messages by electricity without wires, though other scientists, notably William Watson, of England, in 1747, had suggested the use of earth currents for purposes of communication.

Conductive and Inductive Methods.

In 1842, Samuel Morse, of America, the great telegraph pioneer, by sinking metal plates in the water on both sides of a river was able to transmit signals across; and at the same time James Bowman Lindsay, of Scotland, was carrying out similar experiments in this country. Many other experimenters, including Willoughby Smith, in England, followed on along the same lines, and others tried using earth currents, but with less success. Many experimenters, too, devised systems of signalling through space without wires by means of electro-magnetic induction. Most prominent amongst these were William Preece in this country, and John Trowbridge in America. These experiments culminated when Thomas Alva Edison installed a technically satisfactory system of induction for signalling with trains on an American railway in 1887, but after the novelty had worn off, the arrangement was found to be in little demand, and the apparatus was dismantled.

David Hughes.

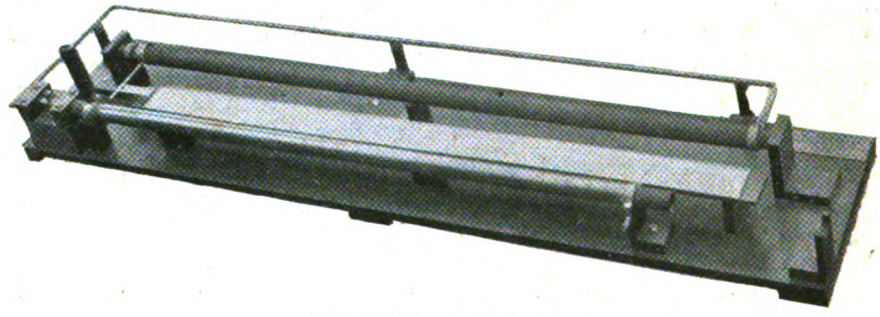
All these methods of wireless signalling were based on either conduction or induction, but, in 1879, experiments were made for the first time in utilising what are now called wireless waves. These experiments, which extended from 1879 to 1886, were carried out by David Edward Hughes, of England, whom we have already noted as a pioneer in telegraphy and telephony. Hughes found that an interrupted current in a coil produced, at each interruption, some form of electric waves which could be detected by a telephone in a circuit which included a loose metallic contact, such as the microphone which he had previously discovered.

Between 1879 and 1888 several leading scientists witnessed these "aerial transmissions," as Hughes called them. Preece, Crookes, and Dewar were amongst them. A small coil was used for transmitting, and reception was carried out with a semi-metallic microphone, the results being heard on a telephone receiver. The transmitter and receiver were in different rooms, about 60 feet apart.

Hughes was not satisfied with 60 feet, but later he was able to obtain a range of 500 yards by setting "the transmitter in operation and walking up and down Great Portland Street with the receiver in my hand and with the telephone to my ear." History is silent on what people who met Professor Hughes in Great Portland Street thought about him.

A Discouraging Report.

On the 20th of February, 1880, Mr. Spottiswoode, the President of the



THE FLEMING CYMOMETER.

This is the instrument to which we referred in Editorial of our last issue. It was designed by Sir Ambrose Fleming, and was one of the earliest forms of wavemeter. As such, it was used in the early days of wireless.

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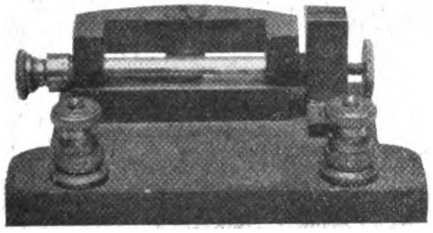
Royal Society, with the two secretaries, Professor Huxley and Sir George Stokes, came to see the experiments, and after three hours' demonstration announced that they could not agree with Hughes' theory that the results were due to electric waves, as they could all be explained by the laws of electro-magnetic



Mercury-Iron Detector used by Marconi. (The Castell Coherer.)

induction. Hughes was so discouraged by this report that he refused to write a paper for the Royal Society until he was better prepared to demonstrate the existence of these waves. Orthodox science had closed the door on the invention of wireless telegraphy, as it has so often attempted to do in the cases of other important inventions.

Present-day workers on television will be interested to read what Sir Oliver Lodge has written of Hughes:

"He was a man who thought with his fingers, and who worked with the simplest home-made apparatus—made of match-boxes and bits of wood and metal, stuck with cobbler's wax and sealing wax. Such a man, constantly working, is sure to come upon phenomena inexplicable by orthodox science. And orthodox science is usually too ready to turn up its nose at phenomena which it does not understand, and so thinks it simplest not to believe in."

The Death of Hughes.

Hughes died in 1900, and left some £400,000 (which he had made by his inventions) to the hospitals of London. He was a great experimenter, and a great man.

There is no doubt that Hughes did not realise that he was using the very waves that had been predicted by James Clerk Maxwell, of Scotland, in 1864, and there was, indeed, another who had similarly used these waves in 1875, Elihu Thomson, of America. Thomson had used the waves and detected their presence at a distance of 100 feet, but he failed to grasp the significance of his experiments, and turned his attention to other investigations.

Clerk Maxwell.

James Clerk Maxwell, whom Sir Oliver Lodge has described as "one of the essential founders of wireless communication," was born in Edinburgh in 1831. He went up to Cambridge, graduated as Second Wrangler, was elected a Fellow of Trinity in 1855, and carried out his great life work at Cambridge. He was steeped in the work of Faraday, and what he set out to prove, and did prove, was that light and electric waves are identical in nature; in fact he founded what is known as the electro-magnetic theory of light.

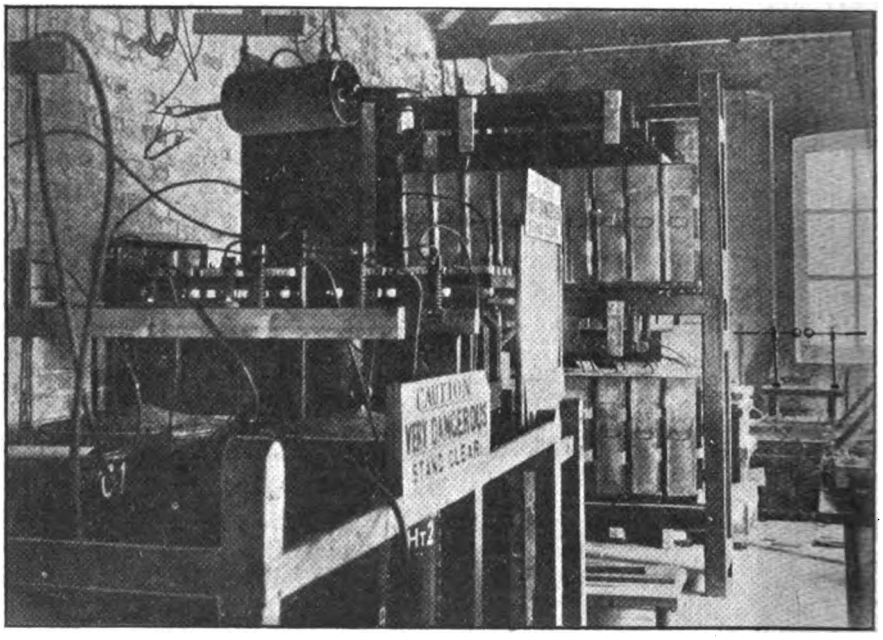
In 1873 he published his epoch-making "Treatise on Electricity and Magnetism." He died in 1879 when he was engaged on a second edition of this work, which has placed him amongst the greatest mathematical physicists of all time. Clerk Maxwell has been described as "a man loved and honoured by all who knew him." His work was by no means confined to the particular line of research which has earned him undying fame, but it is outside our scope to mention his other brilliant discoveries. He not only worked out the properties of these unknown waves, but he gave measurements of their wave-lengths and he predicted that they would travel with the velocity of light. Neither he, however, nor any of his brilliant assistants, was able to give experimental proof of the existence of these waves.

The new theory was received coldly by orthodox science; even so far-seeing an authority as Lord Kelvin refused to accept it, and it was not until 1888 that the theory was experimentally confirmed in Germany by Heinrich Rudolf Hertz, in one of the most brilliant series of experiments that has ever been made.

Heinrich Hertz.

Hertz was born at Hamburg in 1857. He became a pupil, and later an assistant, of the great scientist Helmholtz. In 1883 he became professor of physics at Kiel, where he began a study of Clerk Maxwell's theory, and probably became aware of the fact that Fitzgerald, of Ireland, at a meeting of the British Association in 1883, had suggested that electric waves might be produced by the oscillatory discharge of a Leyden jar. In 1885 Hertz was appointed professor of physics at Karlsruhe, and it was there that he carried out his famous series of experiments.

His apparatus was extremely simple. It consisted of what he called "the exciter" and the resonator. The exciter consisted of a spark gap, with metal plates



MARCONI WIRELESS STATION AT POLDHU, CORNWALL.

Early wireless apparatus used at Poldhu wireless station about the time of Senatore Marconi's transatlantic wireless experiments in 1901. On the extreme left are the transformers. The condensers are carried in metal containers on the wooden rack; and on the extreme right is the spark gap consisting of two steel spheres mounted on insulating rods.

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connected to each spark ball by metal rods. At first, the rods were connected to a Leyden jar, and, later on, to the secondary terminals of an induction coil, by which means a spark was caused to pass between the spark balls.

The resonator consisted of a wire bent in the form of a circle, but leaving a small gap fitted on each side with metal balls. He sent out waves with the exciter, and detected their presence by observing the spark which passed across the balls of the resonator. With this simple apparatus, impossible as it may appear, Hertz completely confirmed all that Clerk Maxwell had predicted, and published his results in a remarkable series of papers, between November, 1887, and December, 1889.

It was at once suggested to Hertz that these newly found waves, which have since been called Hertzian waves, might be used for communicating across space without wires, but Hertz did not know of Hughes' microphonic receivers, and did know that his own receiver was far too insensitive to be of commercial use, so he, too, passed on to other investigations, and the development of wireless signalling was left to other hands.

Sir Oliver Lodge has said that "the enthusiastic admiration for Hertz's spirit and character, felt and expressed by students and workers who came in contact with him, is not easily to be exaggerated." He died at the early age of 37, but to quote Sir Oliver again, "he had effected an achievement that will hand his name down to posterity as the founder of an epoch in experimental physics."

Edouard Branly.

As we have seen, any adaptation of Hertz's work to practical signalling depended primarily on the invention of a sensitive receiver, and it was not long before this was available in the "coherer" which was invented by Edouard Branly, of France.

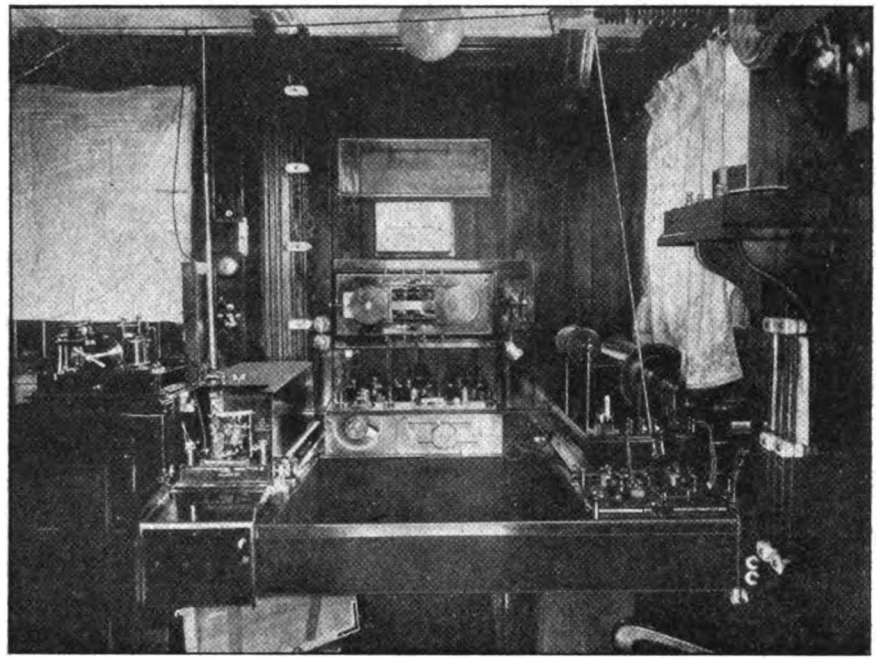
The principle of cohesion had first been observed in 1850 by Guitard, of France, when he observed that dust particles in electrified air tended to cohere together. Sixteen years later S. Varley, of England, rediscovered the principle, and applied it practically in the construction of lightning protectors. Hughes again used the principle for detecting waves in his experiments in 1879, and in 1884 Oliver Lodge and J. W. Clark applied it for clearing rooms of smoke and other fumes.

In the same year, Calzecchi Onesti, an Italian professor, published the results of some experiments in which he had observed that a heap of copper filings between two brass plates became conductive when subjected to the electrical discharge from an induction coil. About this time, Branly was investigating similar phenomena, and found that the conductivity produced in metallic filings by an electric discharge continued for a considerable time, but would at once disappear if the glass tube containing them was tapped.

Branly published these results in 1891, and probably he did not then realise that the effect was produced by the waves which Hertz had discovered a few years previously. Lodge, however, was quick to grasp the great significance of Branly's work, and in 1894 he repeated all Hertz's experiments with a Branly coherer as detector.

Popoff and Lodge.

In 1895 Alexander Popoff, a Russian professor, used an aerial wire, connected to a Branly's coherer and a Morse printer, to record lightning flashes. He undoubtedly foresaw that such apparatus might be developed for commercial signalling purposes, as it afterwards was by Marconi, and it has even been claimed that, in May, 1895, he demonstrated the first practical system of wireless telegraphy. Little more, however, was heard of his work until after Marconi's initial successes in practical signalling.



MARCONI SHIP SET, EARLY TYPE.

A photograph, about 22 years old, of a ship's wireless cabin, showing coil emergency transmitter, right (1½ K.W. main transmitter in separate silence cabinet not shown); multiple tuner and magnetic detector (centre), triple node X-stopper (left), coherer receiver, and morse inker (extreme left).

In this country, Lodge continued his experiments, and in 1894 signalled by Hertzian waves over distances up to 150 yards, but as he wrote many years later: "I was too busy with teaching work to take up telegraphic or any other development. Nor had I the foresight to perceive, what has turned out to be, its extraordinary importance to the Navy, the merchant service, and, indeed, to land and war service, too."

In the United States of America, Hertz's discovery was not followed up so quickly as it was on this side of the Atlantic, but as soon as Marconi had demonstrated practical signalling, the American pioneers joined up in the front rank, led by Nikola Tesla (an Austrian by birth), Lee de Forest, and Reginald Aubrey Fessenden.

(The author is indebted to Marconi's Wireless Telegraph Co., Ltd., for the illustrations in this article.)

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BIRMINGHAM & MIDLAND INSTITUTE

TELEVISION SECTION.

(President: J. B. Kramer, M.I.R.E. Hon. Sec.: F. H. Lane.)

The Birmingham and Midland Institute, with which is incorporated the Birmingham Wireless Association, is a scientific society which was first founded in 1873 and reconstituted in 1895. It has recently formed a Television Section, the first Progress Report of which we have pleasure in publishing below.

PROGRESS REPORT No. 1.

FROM MARCH 8TH TO APRIL 30TH, 1929.

1. Four meetings held during this period: March 8th, 22nd, April 12th, 26th. Average attendance 16.

2. Three books obtained for the use of members. Two copies of Dinsdale's "Television." One copy of Larner's "Practical Television."

3. Reports issued: Technical Report No. 1 on "The G.E.C. Potassium Copper Cell."

4. Apparatus received: One K/Cu cell from the G.E.C., one neon lamp from the G.E.C., one chain drive from the Coventry Chain Co., one Pointolite lamp and resistance from the Ediswan Electric Co., one selenium cell on loan from the Radiovisor Co., one amplifier and batteries on loan from the G.E.C.

5. Laboratory.—Up to the present date most of our experiments have been done in the Photographic Section's dark room, but we hope soon to have space definitely assigned to the section.

6. General.—The chief feature of the period was Mr. Kramer's lecture, given to the Scientific Society, on the "Principles Underlying Television," at which over a hundred people were present.

Experimental Work Done. (A) With the Photo-electric Cell and Amplifier.—A series of experiments were done with the K/Cu cell, the results being summarised in Technical Report No. 1. Work was also started on a complete televisor and receiver in connection with Mr. Kramer's lecture. This machine consists of two Baird discs on separate parallel shafts, connected by a chain. The discs have in them 35 holes 1 m/m diameter, arranged in a spiral of 1 m/m pitch circles. The P/E cell, in a light-tight box, was fixed behind one disc and the neon lamp behind the other. The area of the plate of the neon lamp is 2 square inches. The distance between the shafts is 2 feet 8 inches.

A choke-coupled 4-valve amplifier is connected to the cell as shown in Fig. 1, with the neon lamp in the output circuit. This arrangement will respond only to changes of light intensity. A light flashed on the cell causes a flash in the neon lamp, but a steady light does not cause a glow.

The source of illumination used when trying to use the discs was a Pointolite lamp of 100 candle power, with a concave mirror behind it to project a beam of light. The sitter was arranged about 12 inches away from an optical system which focussed his image on the P/E cell.

Unfortunately no response could be obtained from the cell in this way, due to the low intensity of the light which passed through the 1 m/m holes. Even direct illumination through the holes would give no effect. Up to the present no satisfactory method has been devised which will operate the cell, and until this part of the apparatus is working properly very little can be done on the receiving side of the machine.

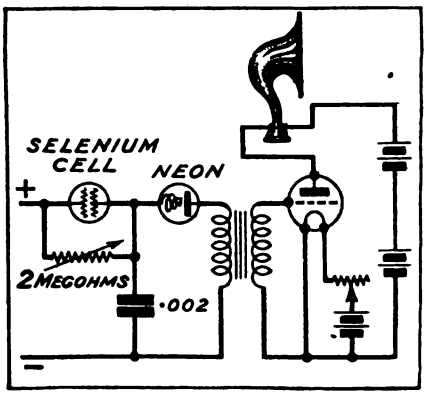

Fig. 2.
Diagrammatic representation of apparatus used by Mr. Kramer during his lecture.

Experimental Work. (B) With Selenium Cells.—The following apparatus was used during Mr. Kramer's lecture (see Fig. 2). It consists of the usual neon lamp flasher circuit, in which the fixed resistance is replaced by the selenium cell, shunted by a high variable resistance—a grid leak.

The oscillations produced are amplified and rendered audible by a one-valve amplifier coupled up through a transformer. When the cell is in the dark the value of the resistance in circuit is so high that the period of oscillation, if any, is about two or three seconds. When light falls on the cell, say, from a flash-lamp 20 or 30 feet away, the resistance falls and the circuit oscillates. The brighter the light the higher the note.

Experimental Work. (C) Synchronising.—Experiments are in progress with a view to getting a motor to run at a perfectly constant speed from D.C. mains, but as much work has to be done on this, descriptions will appear later.

F. H. LANE, *Hon. Secretary.*

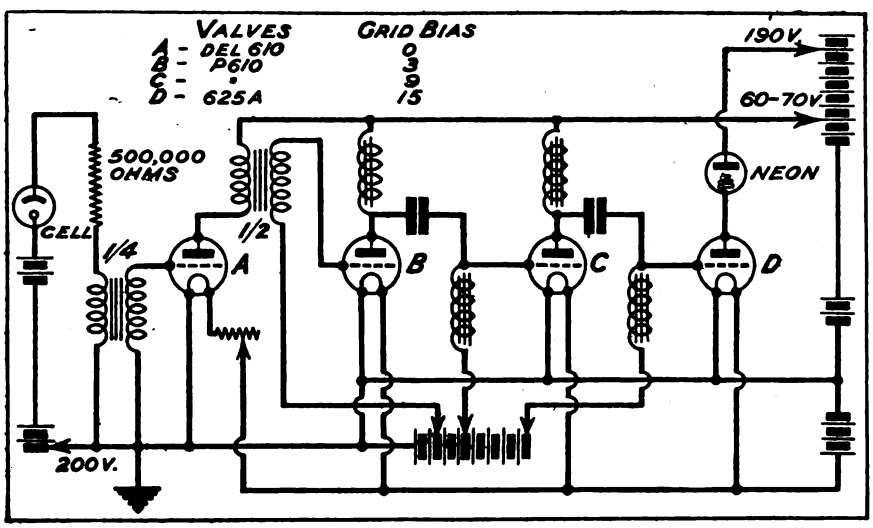

Fig. 1.
Diagram of the choke-coupled 4-valve amplifier, showing connection to neon tube.

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ATMOSPHERICS AND INTERFERENCE IN WIRELESS.

By R. L. SMITH-ROSE, D.Sc., Ph.D., A.M.I.E.E.

In the following article the writer describes the nature and origin of that bugbear of wireless reception, "atmospherics." He also draws attention to the effects which they will have on a received television image.

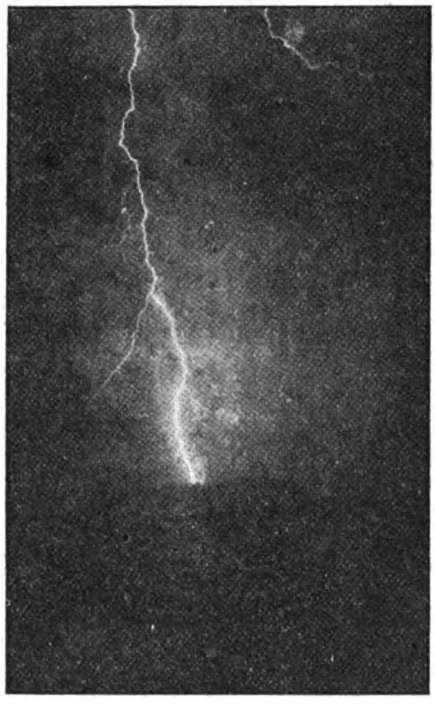
ONE of the greatest difficulties met with in modern wireless communication is that of interference. Almost every day a new wireless transmitting station is set up somewhere and begins to launch forth its waves in an already congested ether, and it has truly been said that the main difficulty of modern wireless reception is not to receive a signal but to keep out unwanted signals.

Interference in wireless is broadly divisible into three classes: atmospherics, unwanted signals—either morse or telephony—and our old friend "oscillation." At about this season of the year listeners to broadcast programmes begin to renew their acquaintance with the crashing, rattling, and hissing noises produced by atmospherics.

Effect on Television.

In the reception of wireless pictures and in television the atmospheric also makes its presence felt by the production of irregular streaks or smudges upon the field of the picture. While these atmospherics may spoil otherwise perfect reception from a nearby station, it is in long distance working that the effect of atmospheric interference is experienced at its worst. In many parts of the world the intensity and frequency of these atmospheric disturbances are so great that many commercial wireless operators are unable to wear head telephones, and automatic recording apparatus is rendered inoperative for several hours a day during certain portions of the year.

As may be gathered from the name which was given to this type of interference many years ago, the origin of these electrical disturbances is intimately connected with the atmosphere. Scientific research on the subject of recent years has shown that they arise from a discharge between separate accumulations of positive and negative electricity in the atmosphere, or between one such accumulated charge and the earth's surface. While it is not necessary that such a discharge should be either audible or visible it is commonly known to our senses in the form of thunder and lightning.



A lightning flash photographed several years ago in mid-Atlantic by the Editor of "Television."

Tests at 1,000,000 Volts.

Some idea of the order of interference to be experienced from a lightning flash has been obtained recently in laboratory experiments with a high-voltage electrical discharge apparatus. Using a plant capable of generating appreciable power at pressures up to 1,000,000 volts, spark discharges were produced over a string of insulators about 6 feet long, the potential difference between the terminals prior to breakdown being about 850,000 volts. At the frequency of 50 cycles per second employed, the current through a maintained arc discharge was about 0·5 ampere.

Effects on Receivers.

Observations carried out on various wireless receivers operating on different wave-lengths between 7·5 and 1,600 metres showed that, while the interference effect of the spark discharge was very serious at short distances it decreased, very rapidly as the distance was increased. Thus, within 50 yards of the spark the strength of the interference was approximately equal to the strength of signals from the London broadcasting station, 2LO, some 10 miles away. As the receiver was moved away from the spark, however, the interference decreased rapidly until at distances greater than half a mile it was quite inaudible on the most sensitive receiver. In the case of all the experiments no audible effect was detectable before the occurrence of the spark discharge, and this result would tend to support the view that all atmospherics in wireless communication are due to actual lightning flashes.

On first consideration it might be thought that the effect of a lightning flash would only make itself felt over a small area, and that ordinary observation shows that insufficient flashes are normally experienced to account for all the atmospherics received. It must be pointed out, however, that natural lightning is an electrical discharge on an enormously greater scale than the relatively puny discharges which we can produce artificially.

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10,000 Amperes!

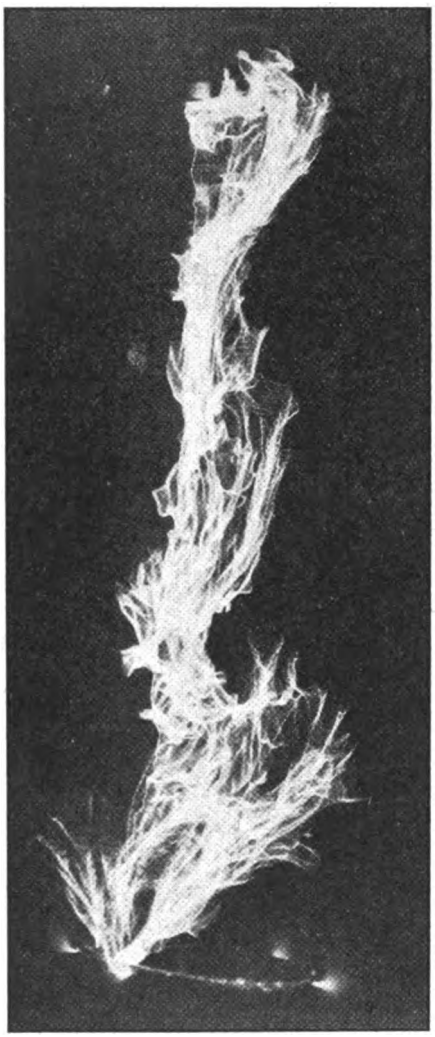
For instance, the average length of a lightning flash is of the order of 10,000 feet as against the 6-foot spark employed in the above experiments; also, the current in the lightning flash has been estimated at about 10,000 amperes as against the half ampere mentioned above. From such figures it can be shown that the radiation from a single lightning flash is from 2,000 to 10,000 times as strong as that from the Daventry high-power broadcasting station. It is thus small wonder that the effects of such a flash are detectable as an atmospheric on all sensitive receivers within a radius of several thousand miles.

As to the frequency with which lightning flashes may occur, we are accustomed in the British Isles to look upon thunderstorms as of comparatively rare occurrence and practically limited to the summer months. As a result of statistics collected over a number of years from 3,000 observing stations, it has been shown that on an average thunder is heard in these latitudes on from eight to ten days per year. In tropical regions, on the other hand, thunderstorms are experienced on from 33 to 60 days per year.

1,800 Thunderstorms Always in Progress.

The complete analysis of this world study of thunderstorms actually observed shows that on an average there are in progress, at any one moment, about 1,800 thunderstorms in different parts of the world. Actually, of course, at any one place, the storms are of more frequent occurrence in the summer than in the winter months. In association with these storms it is estimated that lightning flashes occur at an average rate of 100 per second. When regarded on this basis one begins to understand the possibility of all the numerous atmospherics heard on a wireless receiver being attributable to lightning flashes as their origin.

With the aid of direction-finding and recording apparatus, investigations have been carried out in this and other countries with a view to locating the source of origin of atmospherics at various hours of the day and night. The general result of these investigations (which are still in progress) is to indicate that the majority of atmospherics originate in land areas and particularly in tropical mountainous districts such as South Africa and South America, where it is possible that the convection of large masses of air with subsequent cooling at the upper levels causes the separation of electrical charges which is a necessary predecessor of the lightning flash. All observers appear to agree that large stretches of sea, such as the Atlantic and Pacific Oceans, are seldom the source of atmospherics.



A photograph of a high-voltage electrical discharge about seven feet long. Artificial lightning flashes of this type were employed in connection with the experiments on radio interference referred to on the previous page.

Atmospheric Elimination Impossible.

In addition to research into the origin of atmospherics, many workers have tackled the problem of devising aerial systems and circuit arrangements which will render the receiver immune from the effect of atmospherics. Although some of these are very successful in reducing the undesired effects without disturbing the required signals, there is as yet no known means of entirely eliminating the atmospheric disturbance from wireless receivers; in fact, at the present time, many experts are of the opinion that atmospherics, like the poor, will always be with us.

A Mighty Broadcast.

How the Americans do it.

The thunderous roar of Niagara Falls, and a description of the world's greatest lighting spectacle by aeroplanes, bombs, and billion-candle-power searchlights above the giant waterfall, was broadcast from coast to coast of the United States over the National Broadcasting Company System on the night of June 15.

Microphones in the Cave of the Winds and on the Falls View bridge, above the Niagara gorge, picked up actual sounds of the international "Festival of Lights," and relayed a vivid description of the scenic spectacle.

Graham McNamee and Phillips Carlin headed the corps of radio announcers familiar to American and Canadian listeners, and were posted at points of vantage.

The entire broadcast occurred as a feature of the General Electric Hour, which broadcast a sixty-minute programme from Niagara Falls on that night. It was the 250th anniversary of the discovery of the falls by Father Hennepin.

McNamee was on the bridge, midway between Canada and the United States, and described the scene lighted by a battery of 1,300,000,000 candle-power searchlights, aerial bombs, and electrically-lighted aeroplanes. Carlin was stationed in the Cave of the Winds beneath the actual waterfall, and broadcast the booming "voice" which primitive Indians worshipped.

In the Niagara hotel, beside the upper rapids, the Third Battalion Band from Toronto, Ontario, was stationed for musical interludes.

A nationwide network of stations in the NBC System, headed by WEAF, New York, broadcast the programme.

* * *

What a subject for Television!

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Refractometers of the Critical Angle Type.

Part XII

By Professor CHESHIRE, C.B.E., A.R.C.S., F.I.P.

IN the article which appeared in the June issue of TELEVISION, we dealt briefly with prismatic refraction methods of determining the refractive indices of glass for the various colours of the Spectrum.*

An important instrument for this purpose depends essentially upon the measurement of the critical angle at which light is totally reflected from a plane surface separating two refractive media.

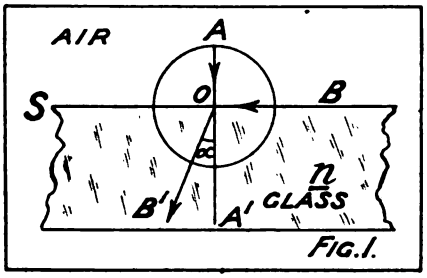
Critical Angle of Refraction.

In Fig. 1, let S represent a section of the bounding surface between, say a piece of glass, with a refractive index n, and air. A ray AO, striking this surface normally will pass through without deviation into the glass below, but if the ray be rotated in the clockwise direction about the point O, the ray passing into the glass will be more and more deviated until, when AO, has been rotated through a right angle into the position BO, the refracted ray will pass through the glass making an angle of refraction α with the normal AA'.

Now we know that the refractive index n is equal to the ratio of the sines of corresponding angles of incidence and refraction, so that when the angle of incidence is equal to 90° and its sine, therefore, is unity

$$\sin \alpha = \frac{1}{n}.$$

This particular angle of refraction is defined as the critical angle, because if we reverse the direction of the light rays in Fig. 1, it is the greatest angle of incidence at which a ray in the given medium, such as glass, can pass out into air, so that the refractive index of any medium in air is equal to the reciprocal of the sine of the critical angle—a relationship of which the optician makes great use, as we shall see.



Refraction at the Critical Angle.

In the table below the critical angles for a number of important refractive media are given :—

CRITICAL ANGLES OF REFRACTION (α).
FOR LIGHT IN VARIOUS MEDIA IN AIR.

Medium.	Ref. index(n)	Critical angle(W)
Water	1·33	48°7
Crown glass ..	1·51	41°5
Canada Balsam	1·53	40°8
Quartz (ord. ray)	1·54	40°5
Flint glass ..	1·65	37°3
Diamond ..	1·71	35°8
Monobromnaphthalene ..	1·66	37°o
Methylene iodide	1·74	35°1

When the angle of incidence of a ray in the denser medium is greater than the critical angle it cannot emerge, but is totally reflected in accordance with the usual laws of reflection. In Fig. 1, as an incident ray $A'O$, in the denser medium is swung about the point O in any direction, it passes out into air with some small loss by reflexion until it reaches an angle of incidence, in the case of crown-glass, of about 41°5. Beyond this angle no light emerges through the point O, but it is totally internally reflected.

In the case of water the critical angle has a value of 48°7, so that light from a complete hemisphere of sky passing into water through a small hole would be compressed into a cone with a semi-apical angle of 48°7. A fish, therefore, swimming in the water outside this cone could not see anything through the hole by which alone the light is assumed to pass into the water; or, put in another way, a fish in an open pond would see a hemisphere, or 180°, of sky compressed into an arc of less than 100°, "precisely as if the water were covered with an opaque roof with a round hole directly overhead."

Angles of Incidence.

Fig. 2 shows rays at various angles of incidence falling upon a surface of water from a point O, in the water The ray OA. has an angle of incidence greater than the critical angle so that it cannot emerge, but is totally internally reflected. The ray OB. falls upon the surface S. at a little less than the critical angle, so that, upon emergence, its angle of refraction is practically a right-angle, so that it grazes the surface S.

All rays, therefore, with angles of incidence less than the critical angle emerge in part, and are in part reflected, whilst those rays incident at an angle greater than the critical angle are completely reflected. The field of view of the fish we have mentioned is shown in dotted lines.

So far we have considered the critical angle, only in the case of a refracting medium immersed in air, or a vacuum more strictly, in many cases,

* A correspondent, Mr. D. J. Mynall, has kindly pointed out two slips in the article on "The Optical Specification of Optical Glasses, etc." in the June issue of TELEVISION, on p. 199, $\theta = d/D$ should be $\theta = d/M$, as a reference to the drawing shows, and the Equation on p. 200 should be $\eta = \frac{\sin \frac{1}{2}(\alpha + D)}{\sin \frac{1}{2}\alpha}$.

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however, as in the case of the spectrometer of the kind depending upon the measurement of a critical angle, we have, as shown in Fig. 3, two dense

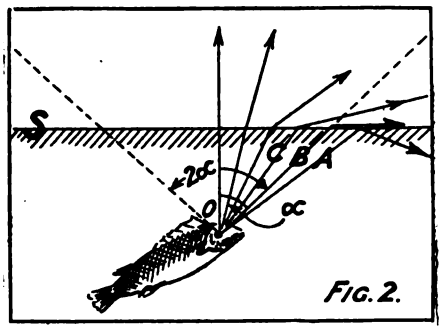

FIG. 2.

Critical Angle in Water.

media separated by a common plane surface S. A ray CO, strikes this surface at the critical angle and is reflected in the direction OB. A ray BO in the first medium, incident at an angle of 90° nearly, would traverse the lower medium in the direction OC. This diagram assumes that the ref. index n_1, of the upper medium is less than n_2, that of the lower medium.

Snell's law of refraction tells us that when a ray falls upon the plane bounding surface of two refracting media at an angle of incidence i, and passes into the second medium at an angle of refraction α, then n_1, and n_2, being the ref. indices of these media we have

$$n_1 \sin i = n_2 \sin \alpha$$

and when $i = 90°$, as in Fig. 3.

$$n_1 = n_2 \sin \alpha$$

so that knowing n_2 and measuring α, the ref. index n_1 could be determined.

This is the principle upon which refractometers of the type under consideration work. It will be noticed that whilst the absolute indices for the two media are n_1, and n_2, respectively the relative index is n_2/n_1 and this index is equal to the reciprocal of the sine of the critical angle—$n_2/n_1 = n1/\sin \alpha$.

Portable Spectrometer.

Figure 4 shows in section a small portable refractometer made by the firm of Carl Zeiss, primarily for the determination of the refractive indices of gem stones, but which may be used for other purposes.

A hemisphere H of a dense glass is mounted so as to be free to rotate about a vertical axis. The gem stone K, or glass plate, to be examined, is placed with one of its flat facets resting on the flat surface of the hemisphere, near to its middle. Optical contact is secured with a drop of an immersion fluid, such as monobromnaphthalene, ($n = 1{\cdot}66$); or in the case of very highly refractive gems methylene iodide ($n = 1{\cdot}74$) may be employed. In any case the refractive index of the immersion medium must be greater than that of the gem under examination, otherwise the reading will give the index of the medium and not that of the gem.

Obtaining Refractive Index.

Light, preferably that of a sodium lamp, is directed upwards towards the centre of the hemisphere H, by a mirror M. The light reflected by the

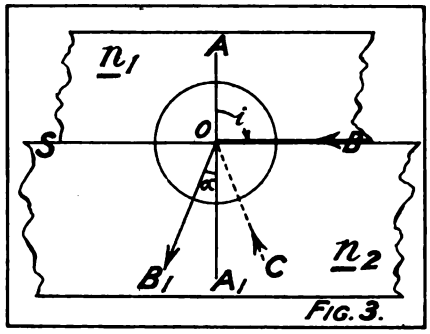

FIG. 3.

Critical angle in the case of two dense media.

surface of the gem in contact with H is collected by the hemisphere acting as a lens, and after reflexion by a prismatic reflector P is brought to a focus on the scale Sk, which is empirically divided to give the refractive index, directly and without calculation, of any gem or glass under examination.

A magnifier OK, is pivoted about a point A, the image of the centre of the hemisphere H, in the reflecting surface of P. In practice, when the necessary adjustments have been made, a horizon line, similar to that seen between sea and sky at the seashore, is seen crossing a vertical scale. The reading at the crossing point, after it has been brought into the centre of the field-of-view of the magnifier, gives the required refractive index.

In an earlier form of the instrument a half-cylinder of glass was used instead of the half-sphere H. By directing the sodium light at glazing incidence along the upper flat surface of the hemisphere H, and using a specimen cut with a 90° dihedral edge, greater accuracy is realised In ordinary use the first and second figures after the decimal point of a ref. index are read off directly, and the third can be estimated.

The advantage of the type of spectrometer we have described is that it gives results quite accurate enough for many of the needs of an optician and, at the same time, dispenses with the necessity in other methods for accurately ground prisms. A few square millimetres of flat surface on the gem or plate to be examined is all that is required.

Refractive Index of a Powder.

It is sometimes required to find the refractive index of a transparent medium which can only be obtained in the form of a powder. This can be done in the case of glass, for example, by immersing the powder in a mixture of benzol and carbon bi-sulphide, and altering the proportions in which the liquids are mixed until the powder becomes invisible.* The refractive index of the liquid, which is in these circumstances the same as that of the glass, can now be determined in any one of the usual ways.

Difficulty sometimes arises, when using white light, owing to the different dispersive powers of the glass and liquid, but this may be overcome by the use of monochromatic light, such as the sodium flame.

* A glass stirring rod disappears from view in an almost startling way when dipped into a bottle of Canada balsam.

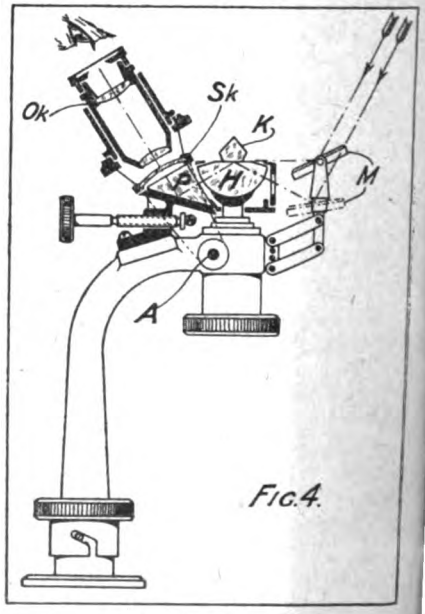

FIG. 4.

Pocket Refractometer.

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Recent Work on Selenium

By E. E. FOURNIER D'ALBE, D.Sc., F.Inst.P.

Dr. Fournier d'Albe is known as a pioneer of the modern theory of selenium and the inventor of the "optophone," a selenium instrument which enables the blind to read books and newspapers printed in ordinary type. He is Consulting Physicist to Radiovisor Parent, Ltd., manufacturers of light-sensitive apparatus.

THE light-sensitive property of selenium was discovered fifty-seven years ago, at the Valentia Island transatlantic cable station in Ireland. The news of the discovery created a profound sensation in scientific circles, for they realised the far-reaching possibilities contained in a substance capable of "turning light into electricity."

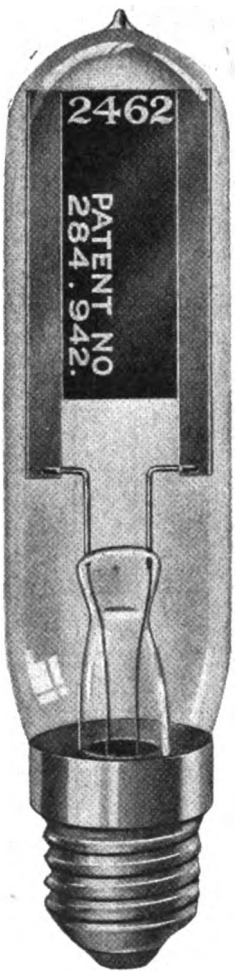
Inventors soon got busy trying to turn that marvellous property to account, and fascinating projects of automatic lighthouses, unmanned boats, burglar alarms, and even television were soon put forward. Unfortunately, these early inventors did not trouble to study the properties of selenium very closely. They asked it to do impossibilities, and when it refused, their inventions naturally fell through.

To-day, selenium has many rivals. Not only have similar light-sensitive properties been found in the natural sulphide of antimony, in thallium oxy-sulphide and other compounds, but an entirely new phenomenon, that of photo-electricity, has been discovered in the alkali metals and utilised in the photoelectric cell.

The sulphides and similar substances have no advantage over selenium, and being compounds instead of elements, they suffer gradual disintegration by electrolysis.

The photo-electric cell, on the other hand, has the advantage that its action is instantaneous. In some processes where very quick action is essential, as in television, this property is very precious, and probably will give the photo-electric cell a permanent advantage in that field.

But it is worthy of note that the only cell which can claim the advantage of instantaneous action is the vacuum cell, where the alkali metal —potassium, sodium, rubidium, or caesium—is mounted in a vacuum, instead of in a gas, which retards the action, though it greatly intensifies it.



The Radiovisor Selenium "Bridge."

Selenium is by far the most efficient agent for producing a current from a given quantity of light. It yields in milliamperes what the vacuum photo-electric cell yields in microamperes. It also responds to the whole of the visible spectrum, to the ultra-violet and to the infra-red up to a wave-length of 15,000 Angstrom units. When illuminated by any terrestrial source, it appears to be chiefly sensitive to the red rays, but that appearance is due to the fact that these rays are the chief carriers of energy in the spectrum. The response per unit of energy is the same throughout the visible spectrum.

Recent researches have gradually unravelled the mechanism of the light-action in selenium. The theory of this action is now generally based upon the conception of ionisation, or the splitting of the atoms and molecules of the substance into oppositely charged ions. The negative ions in the case of a solid like selenium would be free electrons, which move freely within the solid in obedience to electric forces until they are re-absorbed by positively charged atoms. The conductivity at any moment depends upon the number of electrons which have been liberated by the light and have not yet been reabsorbed.

Now the number of electrons liberated in a given time is proportional to the light absorbed by the selenium surface. The number of ions recombined is proportional to the *square* of the number of free electrons. This is best expressed by the equation

$$dN/dt = C - BN^2$$

where N is the number of free electrons, t the time, C a measure of the light energy, and B a constant called the coefficient of recombination.

Equilibrium is reached when the production of new ions by the light equals the number of ions reabsorbed in the same time, that is to say, when $C = BN^2$. This may also be written

$$N = \sqrt{C/B},$$

from which it follows that the value

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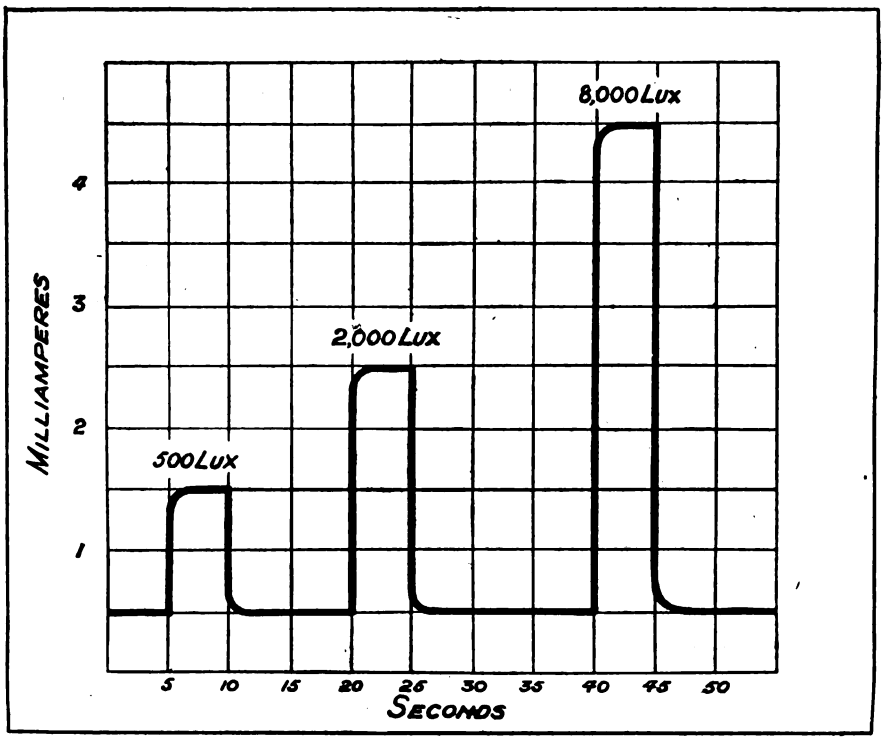

Fig. 1.
SELENIUM UNDER STRONG ILLUMINATION.
The current is proportional to the square root of the illumination.

attained by the conductivity of the selenium—and, therefore, also the current obtained with a given battery—is *proportional to the square root of the illumination.*

This explains why the response of selenium increases more slowly than the light intensity, and why selenium is comparatively inefficient in a very strong light. It also accounts for its marvellous efficiency under feeble illuminations. If, for instance, it gives a current of 1 milliampere under an illumination of 100 "lux" (100 candle-power at 1 metre), it will still give a current of 100 microamperes at 1 lux, and 1 microampere under illumination of 1/10,000th lux.*

Hand-in-hand with the theoretical advances in our knowledge of the properties of selenium there has been a development of practical applications. The automatic street lamps at Barnes are a matter of common knowledge. They are controlled by Radiovisor selenium bridges, which can be exposed to several hundred volts for months on end without suffering deterioration. The same company is producing a complete system of automatic signalling for railways, and also an invisible-ray burglar alarm, which was put into very effective use at the recent exhibition of old silver at Seaford House.

A remarkable property of these new selenium cells is their capacity to follow oscillations of light, and give audible notes up to frequencies of 8000 cycles.

The Radiovisor Bridge.

The bridge consists of a thin glass surface on which a gold grid is fused by a special process, and on this the thin layer of selenium is spread.

This grid consists of a pair of interdigitated combs which form the electrodes, and on this the thin layer of selenium is spread. This forms the actual sensitive surface, and can vary considerably in size for special purposes; the standard bridge having a surface of 27 mm. × 50 mm. The effect of the thin layer of selenium spread on a transparent base is to make the utmost quantity of the material accessible to light, and to leave the smallest quantity to act as an inert shunt to the active portion;

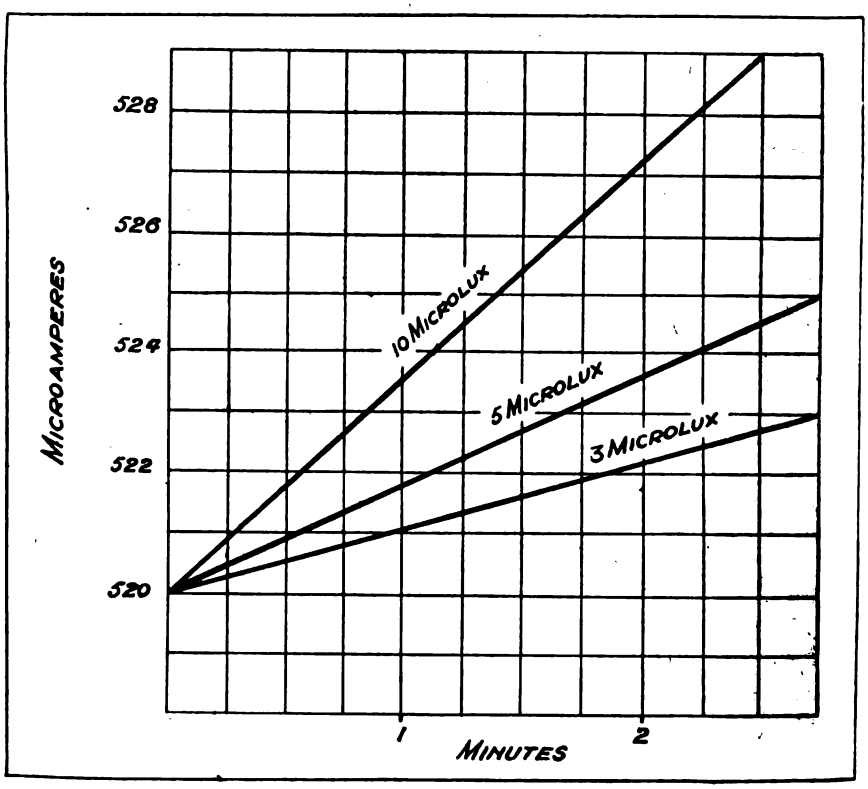

Fig. 2.
SELENIUM UNDER VERY FAINT ILLUMINATION.
The rise of the current is directly proportional to the illumination.

* The complete equation to the light-action curve of selenium is

$$N = C/B \tanh (t\sqrt{BC}) + k\sqrt{B/C},$$

from which any curve for a given illumination can be traced. See the author's paper on "The Efficiency of Selenium as a Detector of Light," in the *Proceedings* of the Royal Society, A, 89, pp. 75–90, 1913.

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so that the ratio of light to dark current is as high as possible. The rigidity of the electrodes is also one of the great factors making for efficiency and permanence.

This sensitive surface, after the appropriate careful and special process of annealing, is held in clips making contact with the gold electrodes, and the whole is enclosed in a glass container with chemically treated gases, and mounted up with an ordinary Edison screw socket. The Radiovisor Bridge thus prepared is permanent, reliable, and is capable of standing up to high voltages—up to a thousand volts. It can be made of any resistance from about half to ten megohms or more, and will pass, in darkness, a current of from 1 up to 250 microamperes, if necessary.

A standard bridge of about 4 megohms will give a change between current in darkness and in light of the order of 100–150 microamps. On any given voltage the curve representing the increase of conductivity with illumination will rise rather steeply at first, and then become a straight line in which change of current is strictly proportional to increase of light, so that the greatest sensitiveness is with weak illumination.

The general law of the response to light of varying wavelengths is that it varies with the curve showing the energy contained in various parts of the spectrum. It is thus sensitive to the infra-red, and this property can be made practical use of. Naturally, the current passing through the resistance of the bridge causes a slight rise in temperature, and for this reason, to avoid injury, a maximum energy dissipation of ·01 watt per sq. cm. of surface should not be exceeded for permanent working: the applied voltage and maximum illumination being considered in this respect.

From the above it will be seen that this bridge can be used directly on any commercial voltages, and can directly work a sensitive relay without magnification. It is capable of being efficiently used in all acoustic applications, so that in the reproduction of music or speech (as for example, from a film), it compares very favourably with any other device.*

* Through the courtesy of Messrs. Radiovisor Parent, Ltd., we recently had the pleasure of attending a highly successful demonstration of the ability of the Bridge in this direction.—ED.

THE PROSPECT

By NOEL SWANNE

TING-A-LING-A-LING!

"Yes, yes; all right; I know," I said, and turned over and went to sleep.

Hammer! Bang!! Smash!!!

"It's gorn 'arf parst eight, sir."

"Yes, yes; I know," I said, and turned over and went to sleep. I dreamed that a B.B.C. announcer turned into a Polar bear, seized me by the shoulder and shook me . . . and shook me again . . . and again . . .

"Do you know it is nearly ten o'clock!" said Marjorie.

"Yes, yes; I . . . What? . . . Ten! Good Lord! Why didn't you wake me up before?" I demanded.

"We did, several times," she replied.

"Ten o'clock! Phew! It's a funny thing that . . . Ten you said, didn't you?"

Marjorie nodded.

"Ten! Well . . . that's a morning wasted."

"Not if you bustle up a bit, dear," suggested Marjorie.

"Yes . . . no . . . Of course not . . . yes . . . well, here goes . . . just toddle along and warm up the bacon . . . . and . . ."

I yawned as she shut the door, and turned over. Anyhow, a morning in bed never did anyone any harm. It is good for you. Some doctors order a morning in bed, once a week. Besides, will it be possible in the future to stay in bed at all? What with wireless and television one never knows what may happen . . . Dear me . . . I suppose I ought to get up . . . I must get up . . . I will get up . . . soon. . . .

* * *

7.30 a.m.—Central chronometer hitches up with Long Acre, streams of electrons leave the ceiling and fall on bed clothes. Active influence comes into play in corners of room, and bed-clothes whisked off.

7.31 a.m.—Sleeping in dressing gown only.

7.35 a.m.—Loud speaker sings "Come into the Garden, Maud."

7.36 a.m.—Death of loud speaker.

7.40 a.m.—Six pips. Picture of bathing belles appears on wall-screen. I spring out of bed, and cut my foot on broken pieces of loud speaker.

7.50 a.m.—Construct long wire rod out of sponge rest while sitting in rapidly cooling water. Use same to switch off televisor, and then get out of bath.

8.2 a.m.—Spill coffee on news-screen. Wipe it up hurriedly, and upset synchronisation, hence top-half shows picture of Winston changing his coat as usual, and bottom half states the Derby was won by two lengths, and the loser was counted out on a foul in the rock garden.

8.5 a.m.—Realise what time it is, and feel *very* ill.

8.6 a.m.—Violent ringing from televisor in study. Find angry face on screen. Put my tongue out at it. Loud speaker splutters. "Why the . . . where the . . . when the . . . !" Still feeling ill, switch the whole lot off.

8.10 a.m.—Jones on the Visor-phone. Just going off to Walton for a round of golf. "Lordy man, you do look sick," he says. Tell Jones exactly what I think of men who a few minutes after 8 a.m. look like he does. Switch off the whole thing.

8.15 a.m.—Violent booming in basement. Fall down the cellar steps. Angry looking official on emergency-screen. Why have I switched off. Several visorgraphs waiting to be sent. Tell him the time, and switch him off too.

8.16 a.m.—Small girl from next door to say that I am wanted on their screen. Seize an egg and two pieces of buttered toast, and streak for garage. Make a dash for the open country.

8.20 a.m.—Portable set in back seat calls—"Swanne, Swanne . . ." I glance behind. Stern face appears on screen. "You are wanted immediately. . . ."

8.21 a.m.—Commit suicide.

* * *

"Are you going to get up this morning at all?" said Marjorie.

"Yes! yes!" I shouted, "and I am never going to bed any more!"

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Distortion—Some Causes and Cures

By WILLIAM J. RICHARDSON

The majority of wireless receivers in use to-day give unsatisfactory reproduction, due to faults of design, adjustment or operation, which give rise to distortion in a more or less acute form. It is not possible for the average broadcast listener to alter the design of his set, but he can do much to eliminate distortion by adjusting and operating his receiver intelligently. The hints given in the following article will materially assist the broadcast enthusiast to this end. The information given below applies equally to receivers intended to pick up television signals.

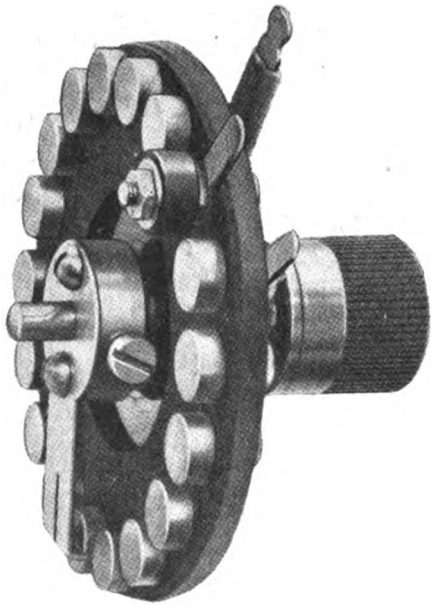
NO doubt all of you at some time or another have experienced the very doubtful pleasure of being invited to a friend's house to listen to the latest acquisition—a home-made wireless set—and been recompensed by hearing a painful travesty of that true quality music which is so often spoken about but found in a surprisingly small number of cases. If you are like me, your fingers must have itched to get at the set and its accessories to put matters right, but in order not to offend, diplomatic tactics have to be adopted so as to point out quietly but firmly where the enthusiast has erred. In the earlier days of wireless most of us were content to be in a position to receive *any* signals, no matter of what quality or type, even unintelligible morse dots and dashes were as a tasty meal to a hungry man, but times have changed.

The Perfection of Details.

From the point of view of the transmission and reception of speech and music, nothing of a revolutionary character has taken place of late. Wireless engineers and manufacturers have been devoting their time and attention to the perfection of details, and rightly so, with the result that there is no valid excuse for anyone possessing a wireless receiver and its attendant auxiliary apparatus which should not be able to delight the ear.

Yes, I know you will say that pure undistorted reception and reproduction is a pleasure denied to the average individual on account of cost, but I beg leave to differ. While granting that the man who is prepared to lay down, say, fifty pounds for his installation should reasonably expect to get the nearest approach to perfection, *almost* the same result can be achieved by anyone who is prepared to give a little time and attention to his set. This costs nothing and will bring about a pleasing return for the time so spent.

To cover all the possible causes of distortion and propound cures for them is beyond the scope of one article, so rather let us focus our attention on the most important. We are on the threshold of a new phase of wireless, now that the broadcasting of television has been promised to us, so do not make the mistake of encountering all the past errors that occurred with sound reception. Rather let us profit by previous mistakes, and not try to deceive the eye in the same way as we have been wont to deceive the ear.



(Photo by courtesy of G.E.C.)

AN EFFICIENT VOLUME CONTROL.

Our illustration shows the new "Gecophone" potentiometer, which is designed to act as a volume control, a most useful adjunct to an L.F. amplifier. By means of 17 tappings a very fine variation of resistance is effected in a positive manner.

Difficult to Dogmatise.

It is somewhat difficult to be at all dogmatic in diagnosing the greatest cause of distortion, but I am inclined to give shoddy components "pride of place." Penny wise and pound foolish is an old adage, but it strikes a very true note where wireless is concerned, so whether your set is used for receiving television or sound signals, do not on any account use parts of doubtful origin. It is better to economise on the total number of intervalve coupling stages, and expend the money saved on good quality components.

Cheap valves, for example, may appear to function all right at first, but they soon begin to lose their emission, while if placed in the detector position they invariably prove to be super microphonic. Nothing is worse than a microphonic howl, and great care should be paid to this point. Then, again, cheap loud speakers veritably "speak for themselves," and the best of efforts directed towards improving the set itself and overcoming distortion frequently are offset by coupling it up to a sound reproducing device to which it is painful to listen.

A Neglected Item.

Keeping for the moment to the question of false economy, there is one item amongst a wireless set's accessories which is so often neglected, and that is the high tension battery. Even in these enlightened

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days we come across people using flashlamp batteries in series because they say it is cheaper to replace one or two faulty ones when they are run down before the rest. It must not be forgotten that the small 4½ volt battery units were never designed for standing up to steady current drains. They are essentially flashlamp cells, as their name implies, and will give good service if used for short periods at a time.

Large Batteries Best.

H.T. battery renewal is a problem which has got to be faced, and it is a step in the right direction towards the cure of distortion if batteries are chosen of high capacity and ample voltage. The initial expenditure is proportionately higher, but they stand up to heavy plate current demands and, of course, their life is much greater than those of their smaller brothers.

During the course of some experiments I have been conducting recently I have drawn anything from 50 to 80 milliamps from large capacity H.T. batteries of a well-known English make. At the end of six months' use the battery voltage had fallen from the original 108 volts to 80 volts, which speaks volumes for the robust construction of the cells. Can you picture what would have happened if small H.T. batteries had been in use? Undoubtedly they would have crumpled up after the first night.

The best solution to the high tension problem assuredly lies in the use of a mains eliminator, whereby the household electricity supply is pressed into service. Here, again, the initial installation may seem rather expensive, but running costs are negligible, and renewals in the form of rectifying valve replacements (where A.C. is in use) are quite infrequent.

Important Points.

Let us now focus our attention on the receiving set itself, for it will be appreciated that a large proportion of the distortion introduced is the direct outcome of our efforts to amplify the original impressed aerial signal. With high frequency circuits too sharply tuned, or a surplus of H.F. stages, we are likely to lose our sidebands and thus cut off frequencies which should be present if perfect reproduction is desired, or, alternatively, if a really high-class television picture is aimed at.

Turning to the low frequency side, we take for our basis the fact that distortion is avoided if the increased signal from the output stage differs from the original only in being greater in magnitude. As was pointed out in an article appearing in last month's issue, as far as any low frequency amplifying valve is concerned, the output current in the plate circuit must be directly proportional to the input grid voltage. To ensure this important detail, the total input volts grid swing to each valve must operate well within that part of the straight characteristic situated on the negative side of the "curve." By following this principle it will also prevent the grid from assuming a positive charge. This factor must be rigidly guarded against and calls for a careful study of each valve's characteristics, so that adequate plate voltages are applied to the anode of the valve together with the appropriate grid bias, neither too much nor too little.

In Passing.

In passing, it is as well to note here that the H.T. voltages actually applied to the set itself do not represent the true plate voltages. There is always some form of impedance present in the plate circuit, and this will account for a certain voltage drop, small in the case of inductive impedances but large when using resistance capacity coupling, and the actual anode voltages differ therefore from that applied to the set terminals.

In choosing the correct negative grid bias it is the *true* plate voltages which must be worked upon and not the battery voltage, and to ascertain what these anode voltages are it is a good proposition to purchase a reliable high resistance voltmeter. Do not employ a cheap low resistance instrument, otherwise you will get fallacious readings, and your money had better be kept in your pocket.

A Question of Design.

It is generally accepted that if an amplifier can be made which does not deviate more than 10 per cent. from the ideal (the ideal being one in which every frequency is amplified to the same extent, and hence gives a horizontal straight line if amplification is plotted against a frequency base), then the acutest ear or the sharpest eye would be unable to detect any difference. If an iron cored transformer is used in the plate circuit, then we are faced with the fact that theoretically the impedance changes with every change of frequency. Furthermore, the magnitude of the impedance is dependent upon the mean plate current flowing through the valve. Can we, therefore, expect to approach straight line amplification?

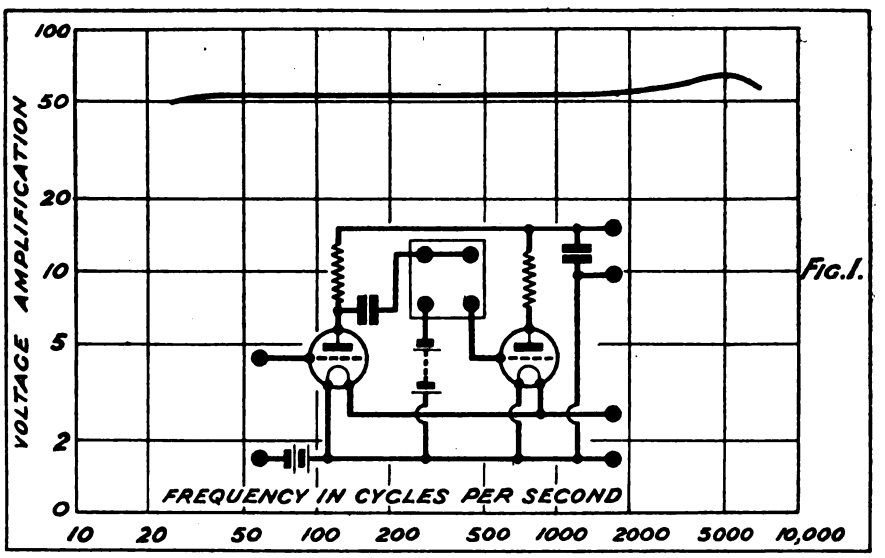

FIG. I.

Voltage Amplification—Frequency curve of the R.I. "Hypermu" L.F. transformer. The first valve in the recommended circuit is a DEL 610; the second a Cossor Stentor Six. The first plate resistance is 30,000 ohms; the second 3000 ohms. non reactive. The coupling condenser between the plate of the first valve and the transformer has a value of 1 mfd. The condenser across the H.T. terminals is 5 mfds.

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Fortunately, the answer is in the affirmative, due to the fact that our low frequency transformer is not quite such a simple instrument as one at first imagines. One of the main features in the design of this transformer is to keep the impedance of the primary winding as high as possible at the low frequencies consistent with small self capacity at the high frequencies.

By careful design and bearing in mind that in addition to the inductance of the primary and secondary windings we have present a leakage inductance, primary and secondary resistance, and primary and secondary winding self capacities, it is possible to produce a component which gives a reasonably steady amplification value throughout the whole range of audible frequencies. Obviously, a cheap transformer cannot be designed to approach this degree of accuracy, and hence distortion takes place; so to avoid any trouble in this direction choose a reputable make. Actual bulk is not always a criterion, owing to the improvements which have been effected in the iron used for the core, and in this connection it is interesting to see the published N.P.L. curve of the latest R.I. transformer, the "Hypermu." The evenness of response at all frequencies is particularly good (see Fig. 1), and yet the transformer is relatively small in size.

R.C. Coupling Desiderata.

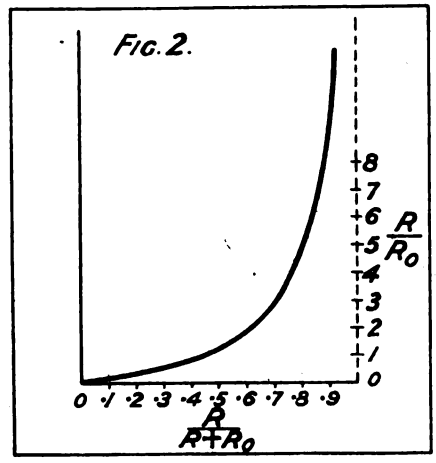
To achieve the best results in amplifiers for television work where the frequency range to be covered for amplification exceeds that of the audible frequency range, it is found that resistance capacity coupling meets the case in a really excellent manner. To avoid distortion here, it is necessary to note that the real secret of success lies primarily in the selection of suitable valves and component values. Empirical formula are available for those who wish to work out the values for themselves. If we consider the anode resistance alone, we have

$$\text{Amplification} = \mu \frac{R}{R + R_o}$$

where

μ = Magnification factor of valve.
R = Resistance in plate circuit.
R_o = Impedance of valve.

If a curve is plotted for this formula it will resemble that of Fig. 2,



Curve plotted for the formula given at the foot of column 1 on this page.

and we can see that for most purposes the resistance in the plate circuit need not exceed about four or five times the valve impedance. While it is admitted that because grid bias is applied to a low frequency valve to accommodate the grid swing, and that this makes the A.C. working impedance of the valve much higher than those issued by the makers, since these are given for maximum anode volts and zero grid bias, the formula quoted will serve for most general purposes.

The Grid Leak and Coupling Condenser.

Coming now to the grid leak, we can consider this component as being virtually in parallel with the anode resistance, and in consequence it must be much higher in value. About four or five times the value of the anode resistance will suffice, and be sure and choose a grid leak of well known make, or trouble will occur. If the R.C. stage precedes a valve of the super power class, a wire wound resistance of from 100,000 to 250,000 ohms is advisable.

With reference to the coupling condenser, be sure that the insulation of the dielectric is above reproach, and to this end mica condensers are preferable. To calculate the coupling condenser value the following formula should prove useful:—

$$C = \frac{\mu_o}{6{\cdot}28 R_g \times f \sqrt{1 - \mu_o^2}}$$

where

R_g = Grid leak value in ohms.
f = Lowest frequency to be amplified.
C = Capacity in farads.
μ_o = Fraction of maximum amplification desired at f.

Thus, if the grid leak is to be half a megohm with a plate resistance of 100,000 ohms, and μ_o is ·9, then, at a frequency of 50, C should be about ·015 microfarad.

Note that when using more than one stage of R.C. coupling it is necessary to use somewhat larger coupling condensers if the same percentage of amplification of the lower frequencies is to be maintained. In the case quoted, μ_o should be $\sqrt{\cdot 9}$ for two stages, $\sqrt[3]{\cdot 9}$ for three stages, and so on. The condenser capacity values calculated are the minimums, and it is useful to use larger values if it is desired to be absolutely on the safe side.

Overloading.

Due attention to these details of R.C. coupling should remove any trouble likely to arise from distortion, and demands of space preclude further examination of other interesting points which arise in this connection. Before closing, however, there is one fruitful source of faulty wireless reception in both speech and television sets which must not be overlooked, and that is valve overload distortion due to the use of unsuitable valves. It is generally in the last stage that this occurs, although the possibility of similar defects in preceding stages must not be lost sight of.

One of the most reliable indicators of distortion is a milliammeter. If placed in the plate circuit of the last valve the needle will take up a certain steady position when no signals are being received. Any appreciable movement of the needle from this value, even when the strongest signals are being received, indicates overloading due to an unsuitable valve, insufficient high tension or incorrect grid bias. The capability or otherwise of a valve to deal with definite grid inputs was dealt with in this journal last month in an article concerning power valves, so the facts need not be reiterated, but remember that a good meter is indispensable in this connection.

At a later date the writer hopes to give actual practical results of some tests on distortion as applied to sets used for receiving television, as this is of particular importance to readers.

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Light: The Essential of Television

Part X.

By CYRIL SYLVESTER, A.M.I.E.E., A.M.I.Mech.E.

The following is the concluding article of the series on light which our contributor has been writing month by month. In this article he deals with methods of artificially illuminating subjects or scenes to be televised.

IN this, the last of this series of articles on the importance of, and the effect of, light upon subjects which will come under the "eye" of the Televisor, there remains very little for me to do but to deal with a few essential points which may be said to be of a general character; which could not be discussed among the essentials of light and its effects alone.

A scene under normal daylight will be witnessed in clearness according to the quality of the light by means of which it is seen. With high intensities of light, the intensity for various subjects may be too high. This is not a serious fault since, through the medium of filters, the intensity may be decreased until it reaches the correct value for broadcasting. It will, however, be very difficult to "build up" the intensity of normal daylight. This is a question for those versed in optics to consider.

It should be remembered that the relation between the televisor and the camera ceases to exist at this point. That is, under low intensities of light the time of exposure for a camera can be varied so that the effect is a picture which, to all intents and purposes, may have been taken under much higher intensities. In Television, when an animated scene is being broadcast, all movements occur over a certain period of time. This instant of time cannot be varied.

Another important factor to be considered, and this applies equally to artificial light, is that the angle from which a scene is accepted must be correct from an illumination point of view. To describe this briefly it may be said that the light source must be behind or high above the television transmitter. The reason for this can best be explained by saying that "*a bright light source in the line of vision reduces one's ability to see.*" It may, therefore, be said that if the eye cannot clearly define a scene, the chance of successful transmission is very remote.

I will discuss this from various viewpoints.

In Fig. 1 is illustrated a white screen, A, upon which it is assumed some letters or figures are printed in black ink. In this illustration, L is a light source; it is to be assumed that the eye is looking at the screen. Brief consideration of this illustration will serve to show that the light rays from L are intercepted at two points; by the screen and by the eye. The letters on the screen are seen only by the light that is reflected from *the screen*, so that we have two

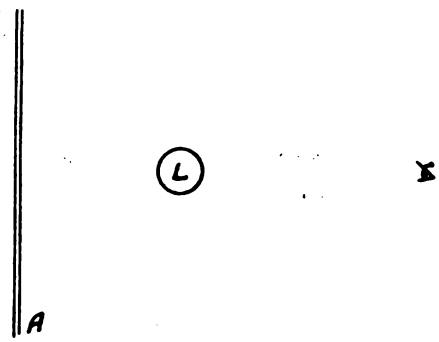

Fig. 1.

conditions of light entering the eye; direct light from L and reflected light from the screen.

Only a small pencil of light enters the eye from L, so that, from a vision point of view, the retina of the eye is blurred by a bright spot. The intensity of the reflected light is much lower than that of the direct light, so that the latter predominates and the portion of the retina occupied by the spot becomes blind. In this way a certain portion of the lettering upon the screen cannot be seen.

By raising the light source, as illustrated in Fig. 2, practically the whole of the light received on the retina is reflected light of not too high intensity, so that the whole of the lettering will be seen.

In normal daylight the sun in a clear sky may, under certain conditions, be considered as a bright light source. From a Television point of view the best results will be obtained if a scene is accepted in such a manner that maximum advantage is taken of the light rays reflected from the various objects in the scene.

To illustrate this let us consider an important sporting event which would be broadcast under normal daylight—the English Cup final at the Wembley Stadium. This would be accepted by the Televisor from either ends or sides and, since the whole of the playing ground would be included, from the roof of the stands. The sun appearing over the top of the stands immediately opposite the point from which the scene was being accepted would considerably affect the reception; a portion of the transmitter would be, in effect, blind. The alternative is, of course, to accept the scene from the opposite side—with the sun behind the transmitter. In this way the whole of the light received from the various fixed objects, and the players moving about on the field, will be reflected light, and they will be clearly seen.

I have dealt to some extent with the design of lighting units which may be used to obtain certain effects under artificial light; directional effects which will enable objects to be seen in their three dimensions. I would now say a few words about the necessity for general illumination. A scene or setting must be illuminated in a general way before the directional effects are produced. That is, considering a drawing-room scene, a general system of illumination will enable the shape of tables, chairs, sideboards and lamp standards, etc.,

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to be determined. Their decorative features, however, will not be revealed. The method of providing the general illumination will depend, of course, upon the size and character of the scene.

Ordinary lighting units are useless for this purpose. In the first place

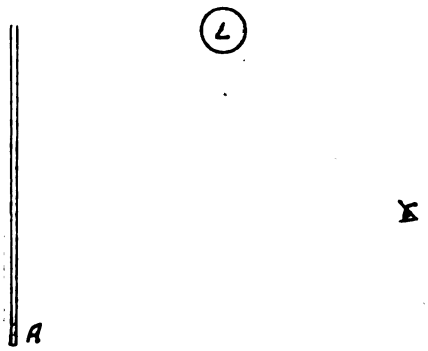

Fig. 2.

the intensity must be high ; it must also be well diffused. It must not produce shadows which cannot be eliminated or reduced to correct value by means of directional lighting units.

In Fig. 3 is illustrated a lighting unit which will illuminate a large setting. It consists of a number of tungsten filament lamps accommodated in a square or rectangular type of reflector. The unit is made up of $\frac{1}{16}$in. sheet iron lined with polished aluminium. This is much better than mirror glass, since the light will be more diffused. The lamps should have a 1000 watt rating, and should be fitted in appropriate Goliath holders of the porcelain backplate pattern. The distribution of light, or the area which can be illuminated with this unit, can be more or less controlled by raising or lowering it as the case may be. It may be said, in fact, that the quality of the illumination can be controlled by fixing the unit at a suitable height.

Let us assume, for instance, that with the directional lighting units in position the effect of light and shade is not quite what it should be. It should be remembered that the directional light must pierce (or neutralise) the downward directional light. This can be done in two ways By increasing the intensity of the directional lighting units, or by decreasing the intensity of the general lighting unit. The intensity of the directional lighting units can be increased by using more concentrating type reflectors, but the area illuminated is diminished.

If, therefore, a section of a setting is just covered by illumination from a directional lighting unit, using a more concentrating type unit will not assist matters at all. It will, in fact, cause distortion so that the true shape of the setting cannot be identified. By raising the general lighting unit the intensity is decreased ; this in proportion to the square of the distance of the unit from the objects illuminated. The decreased intensity permits the effect of the directional lighting units to be emphasised so that the general effect is, relative to the general lighting, an increase in the intensity of the directional lighting units without any alteration to the area illuminated.

I would say a few words with regard to the illumination of countryside settings under artificial light. I have pointed out that the spectrum of normal type gasfilled lamps is very much different to that of normal daylight. If the illusion of a scene is

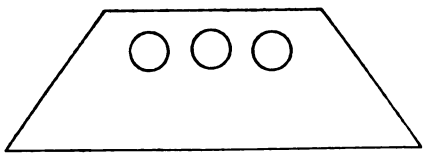

Fig. 3.

to be complete the spectrum must be rectified. Artificial sunlight, for instance, can be obtained by using colour filters of amber glass. The green on trees can be emphasised by projecting green light upon the branches through the artificial sunlight rays. In the same way the red bricks of the front of a house can be made more prominent by projecting red light upon it. This light filtering and projection must be carefully carried out or the general effect will be bad ; that is, the light must be perfectly controlled. There must be no overlapping of colour. If the front of a house, for instance, is to be illuminated with red light, a green door, if receiving some of the light, would appear reddish-black. This can be controlled by the use of several small units with red colour filters with the angles of cut-off between lamp and reflector edges adjusted to obtain the correct beam spread. There is no reason why red light should fall upon the door. A square type of unit fitted with a green colour filter will effectively illuminate the door.

In the same way artificial moonlight can be obtained by using a colour filter of the correct quality ; not by decreasing the voltage applied the lamps terminals. The construction of a unit suitable for producing either artificial sunlight or moonlight is illustrated in Fig 4 ; for artificial sunlight the reflector is gilded and the face covered with amber coloured frosted glass. For artificial moonlight the reflector is of mirror glass and the filter is of deep blue frosted glass.

In conclusion I would say that all gasfilled lamps should be run at their rated voltage ; this not from an economic point of view but from considerations of colour quality. It is, indeed, better to over-run the lamps ; that is, from a colour quality point of view a 200 volt lamp will give better results if used on 220 volts. The light will be much more white and the spectrum will be nearer to that of normal daylight. The lamps' lives will be decreased, but the expense of colour rectification will also be decreased.

I would advise readers of this series of articles who are experimenting in the broadcasting of Television under artificial light to make several reflectors, and to obtain suitable lamps and colour filters. The filters are ordinary gelatine sheets which may be obtained from any firm who market stage-lighting equipment. Light control, and the effect of coloured light upon coloured material, is an interesting

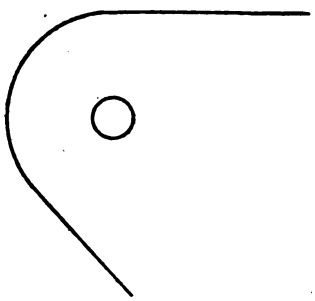

Fig. 4.

science, a science which must be understood by all Televisionists.

If any reader experiences any difficulty in his experiments I will be pleased to help him.

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THE CONSTRUCTION OF EXPERIMENTAL TELEVISION APPARATUS

Part II

By A. A. WATERS

Mr. Waters, in collaboration with Captain F. Wilson, recently demonstrated before the Television Society a Shadowgraph Transmitter and Receiver which they had designed and constructed.

The following is the second of a series of articles which Mr. Waters will write for "Television," giving constructional details and information of value to amateurs.

IN the preceding article of this series we dealt with the tools required to make a simple piece of apparatus for use in television research work.

Construction of Scanning Discs.

We will now consider the construction of scanning discs, such as were used by Captain Wilson and myself in our experiments with shadowgraph transmission and reception. The first disc tried was one with a double spiral of 24 holes, as shown in Fig. 1. Improved designs of disc were devised later, but I suggest that the beginner should start with this one, as it does not offer any serious constructional problems.

The material required for making it can be obtained from a sheet metal stockist, and care should be taken to see that the piece selected is flat. The particular metal used in our experiments was aluminium and was purchased from Messrs. Braby & Sons, Ltd., of Euston Road, the size being 24 in. square and the thickness 20 SWG (standard wire gauge).

Cutting the Disc.

We must now consider the method adopted to cut and mark off the disc. One requires, of course, a suitable tool for this job; the tool we use is a pair of trammels with one end ground to a small cutting edge, as illustrated in Fig. 2.

First, find the centre of the material and drill a hole 1/16 in. dia. This is done to prevent the point of the trammels from slipping out of the centre when cutting. The actual cutting should be done with the aid of a little paraffin oil on the cutter as a lubricant.

Next, lay the material on a flat surface and hold the point of the trammels firmly in the centre, and, with the right hand, proceed to cut by applying light pressure. This operation should be repeated on both

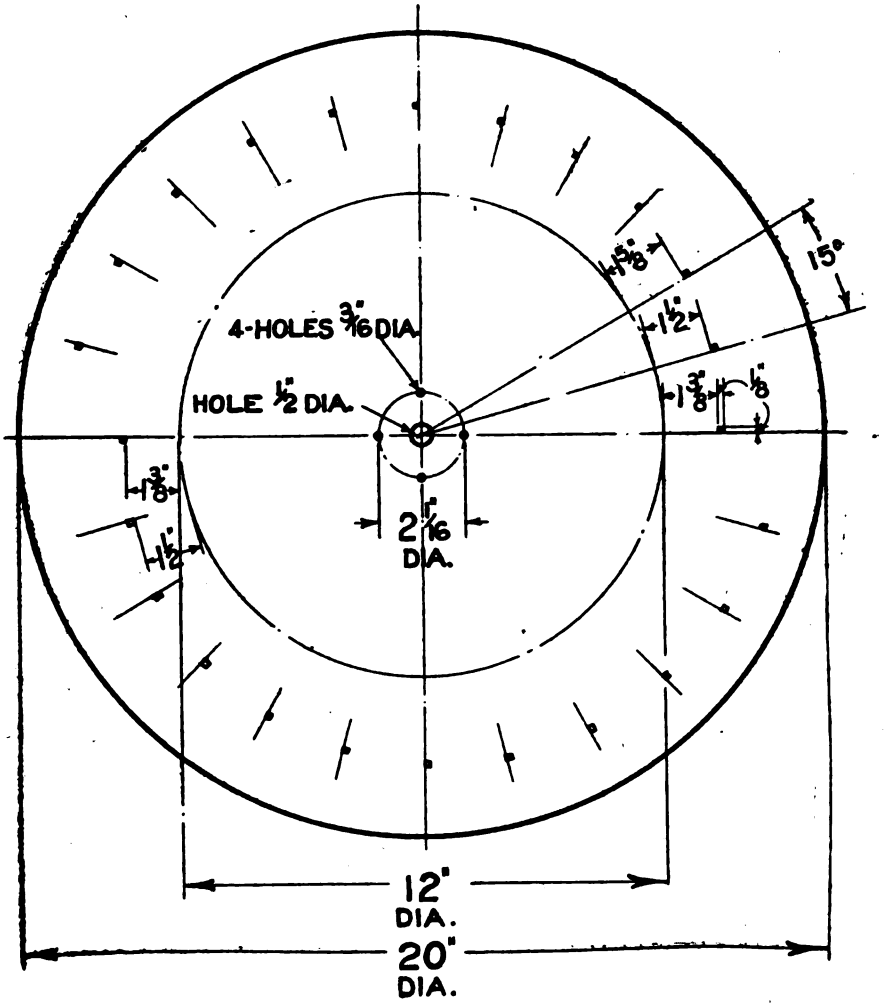

Fig. 1.
Layout of a double spiral 24-hole disc.

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sides of the material alternately until the cutter begins to break through, the time necessary to complete the job being usually not more than ten to fifteen minutes. Care should be taken when breaking the outer metal away from the disc, otherwise distortion of the material will result and the disc will not run true when mounted for use.

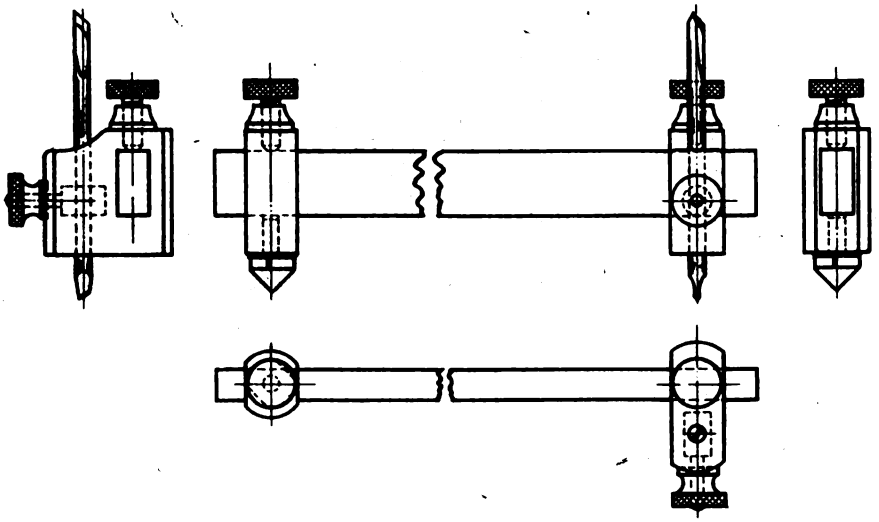

Fig. 2.
A pair of trammels, with one end ground to a small cutting edge, for cutting out discs.

The Marking Process.

We will now consider the " marking off " process, and as there are several ways of doing this, I will describe the method which I consider the most simple. A pair of dividers is necessary for this operation, and I would advise the experimenter to make sure that the points are quite sharp.

You will notice that there are three circles in the diagram (Fig. 1); the object of the 12 in. dia. circle is to simplify the process of marking out the positions of the spirally arranged square holes. We measure radially from the circumference of this circle, and not from the centre of the disc, thus avoiding the necessity of using dividers of exceptionally wide span.

Set the trammels to scribe a 12 in. dia. circle, and divide it into 24 equal parts by scribing a series of equally spaced radial lines on the disc. From the points where these radii cut the circumference of the 12 in. circle set the dividers and mark as shown in the diagram.

Drilling the Holes.

The disc being of the double spiral type the dividers should not be moved until the corresponding holes on both spirals have been marked off. After drilling these holes with an 1/8 in. drill, the next step is to square them with the aid of an 1/8 in. square file, and finally with a drift, details being given in Fig. 3.

The drift should not be used until the apertures have been squared with the file, thus leaving very little metal for the drift to remove.

The results obtained from this disc were remarkably good, as, when it was running at a slow speed, one could actually see how the shadowgraph built up into small squares. When trying for improved results a double spiral disc having 30 apertures was used. This is described later.

Mounting the Discs.

We have next to consider the mounting of the disc on the motor spindle. The mounting itself is turned from brass or steel and details are given in Fig. 4. The principal object of this mounting is to permit of discs being interchanged, and this is effected by taking off the four securing screws, the 1/2 in. dia. hole in the disc registering with the mounting.

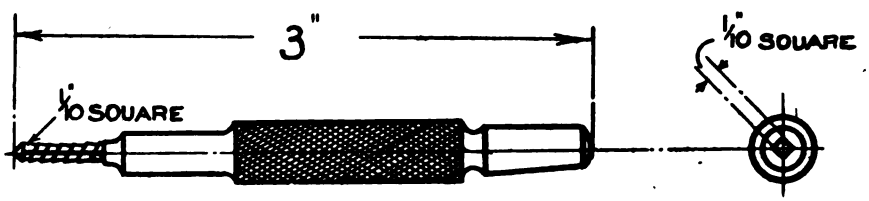

Fig. 3.
Details of the drift used for making square holes.

This arrangement proved of great value in our experiments with various sizes of apertures and spirals.

A 30-aperture single spiral disc with 1/10 in. square holes is shown in Fig. 5. You will notice that the marking off is accomplished in a similar way to that described for the previous disc, except that the number and size of apertures are different.

Testing for Accuracy.

After a disc is constructed, it is advisable to test the spiral for accuracy. This is best done by securing a piece of white paper to a flat surface, drawing a line across the paper, and laying the disc upon it so that it can be rotated about a fixed point. Turn the disc until the line appears in the centre of the first aperture and then mark the shape of the square on the paper. Repeat this until all twelve squares are marked: you will then have a row of squares the position of which will show the accuracy of the marking out.

To obtain the best results both spirals, of course, should be identical.

Separate Transmitter and Receiver Discs.

Having gained experience with the single-disc transmitter and receiver we can now turn our attention to the construction of pairs of discs, for use where separate discs are employed for the transmitter and the receiver respectively. It is immaterial what spiral one uses, provided that both discs are identical. When making the apertures, therefore, the discs should be clamped together.

When carrying out our first experiments with a separate transmitter and receiver the question of synchronisation naturally engaged our foremost attention. If the experimenter has an A.C. mains supply the problem is fairly simply solved by the use of two synchronous motors. In our case, 200-volt D.C. was the only supply available, and

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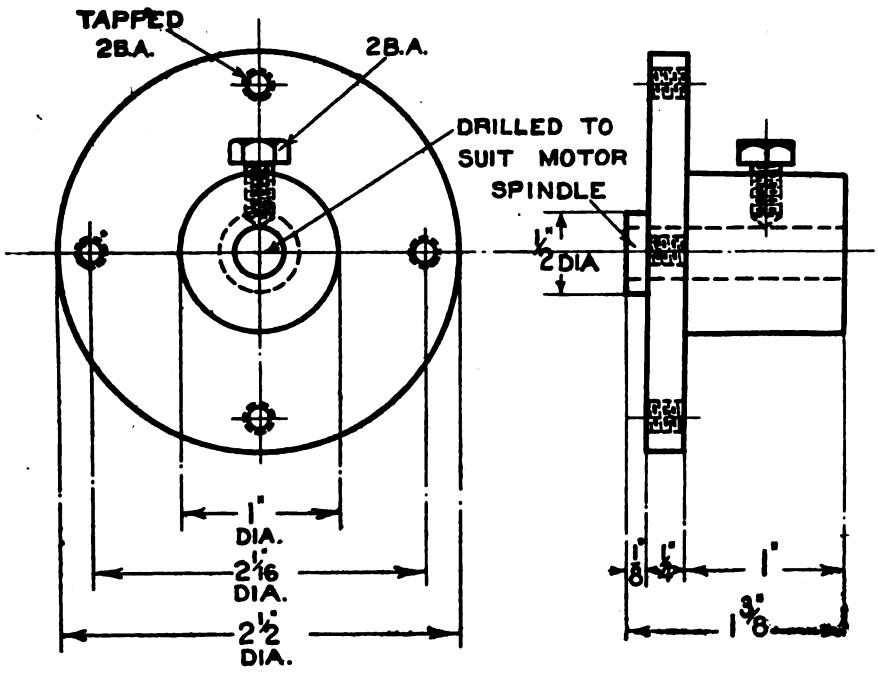

Fig. 4.
Details of the disc mounting.

to convert this to A.C. would have meant considerable expense. After carefully studying the matter we decided to experiment with the D.C., and find out if it was possible to keep two D.C. motors in synchronism with the aid of resistance control.

Synchronisation.

The first experiments were tried with two cheap motors, the current being supplied from a 12-volt accumulator. Failure, however, resulted, owing to bad brushes and to the bearings becoming warm.

Two better motors had, therefore, to be obtained to complete our experiments, and these unfortunately proved rather expensive. We had, however, the satisfaction of achieving what we set out to accomplish. The motors were of the Universal type made by the G.E.C., and are rated at 200-220 volts, 1/40th H.P. They can be used with A.C. as well as D.C.

To control the speed of these motors it was found that the resistances should be very smooth in action, so it was decided not to attempt to make them ourselves. Very good ones, however, are obtainable from Isenthal & Co., Ltd., of North Acton, London, W.3, the Type No. being J.C. 0·3 amp., 1100 ohms.

Magnetic Control.

The results obtained from the "separate" receiver and transmitter will undoubtedly open up further lines of research to the experimenter. In the receiver used by Captain Wilson and myself we found it desirable to add a magnetic control. This consisted of a horseshoe magnet placed so that the disc ran between its poles. On the outer periphery of the disc were four steel rivets, evenly spaced. When the magnet is energised with current controlled by a small resistance it reduces the speed at which the disc is rotating. Therefore, if the speed of the receiver disc should happen to be slightly greater than that of the transmitter disc the magnetic brake can be brought into action, very smooth control resulting.

Supply Voltage.

This method is, of course, experimental only: much, too, depends upon the steadiness or otherwise of the mains supply voltage. I will, however, leave the constructor to judge of its merits for himself. I do not think he will be disappointed.

In my next article I will give details of the various light sources that were used in our experiments, with information as to how to construct the apparatus employed.

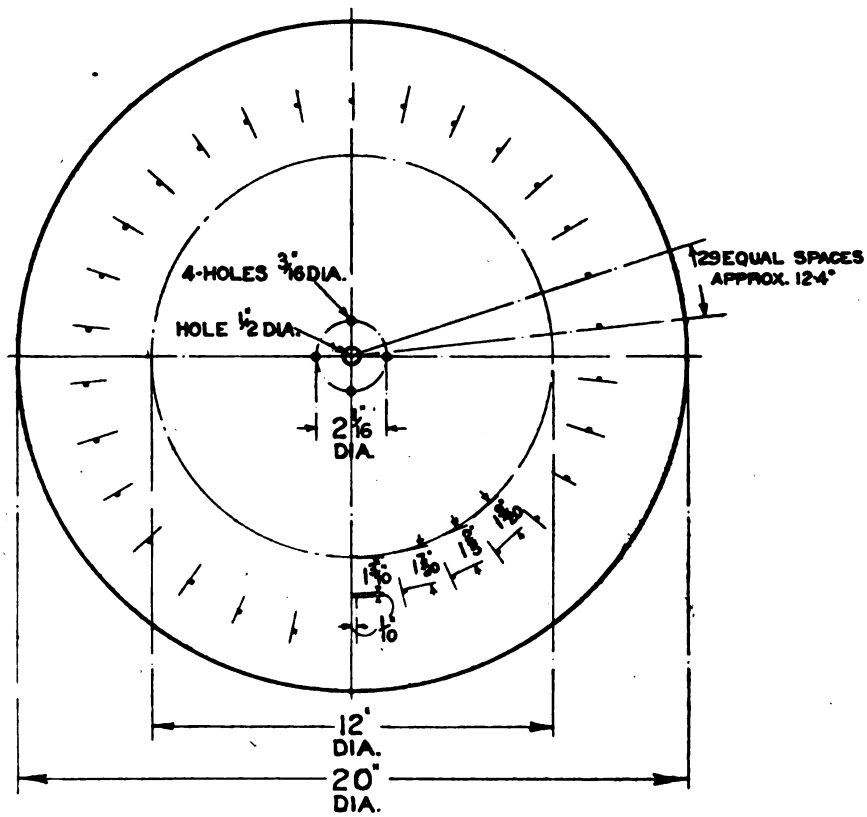

Fig. 5.
Layout of a single spiral 30-hole disc.

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Sydney A. Moseley

Writes from Berlin

MY DEAR EDITOR,—So you are athirst for more news from this interesting centre. I imagined somehow that on receipt of my first letter your appetite would have been sharpened.

The fact is that, since I wrote to you last, considerable developments have occurred which should please every reader who has followed the fight for the recognition of the Baird system of television in England and abroad.

In my last letter to you I referred to the officials of Germany as being enterprising.

They have been exceedingly charming as well.

Both State-Secretary Dr. Bredow (see cover illustration) and President Kruckow have fêted us and given us every possible help. Dr. Bredow is the ruling spirit of the Rundfunk, while President Kruckow is in charge of the Reichspostzentralamt—a huge organisation housed in one of the most wonderful buildings I have ever seen.

I enclose a photograph of it, the first ever published, which the President was good enough to give me; but this gives no conception of the originality and beauty to be found in the interior.

While being futuristic, it is eminently practical, and one is gaping at its outlines even though one has an urgent errand with the President!

From another photograph I enclose one gets some idea of the personality of the man who rules over this huge establishment. The president is chief in fact as well as in name.

In company with Mr. Hutchinson, Managing Director of the Baird Television Company, we were shown the up-to-date methods which characterise the working of this government department, and when (later) John Baird himself came over he was enthralled with the excellent workmanship of the radio and television apparatus in the Post Office. To be perfectly truthful, there was nothing of a revolutionary character, but the great pains exercised in the making of even the smallest gadget and the thorough organisation, typical of all German undertakings, won our unanimous approbation.

Baird Apparatus in German G.P.O.

All the more pleasing is it, therefore, that for the first time in history *the Baird apparatus has been installed in this building* so that the Baird engineers and our German friends will co-operate in further developments. The German authorities openly expressed wonderment at Mr. Baird's latest achievements. They had never seen anything like the extended view scenes and were so amazed at what they had seen that one of my best friends in Germany suggested, rather shamefacedly, afterwards, that perhaps what he had seen was not direct television but a film! He was very much relieved when I was able to assure him that what he had seen was really television.

The lunch that State-Secretary Dr. Bredow gave to Mr. Baird, Mr. Hutchinson and myself was somewhat historic, and I make no apologies for referring to it. Besides Dr. Bredow, Mr. Hutchinson, Mr. Baird and myself there was President Kruckow, Dr. Magnus, managing director of the Rundfunk, Dr. Reisser, chief engineer of the German B.B.C., and Dr. Bannietz of the G.P.O.

The result of all these interesting conferences has been the formation of a company in Germany whose main object will be the development and broadcasting of television with governmental blessing. The underlying purpose is purely scientific, although, of course, in order to further science it must have some commercial basis. This important Company is made up of the Baird Television Company, the

President Kruckow, of the German Central Post Office.

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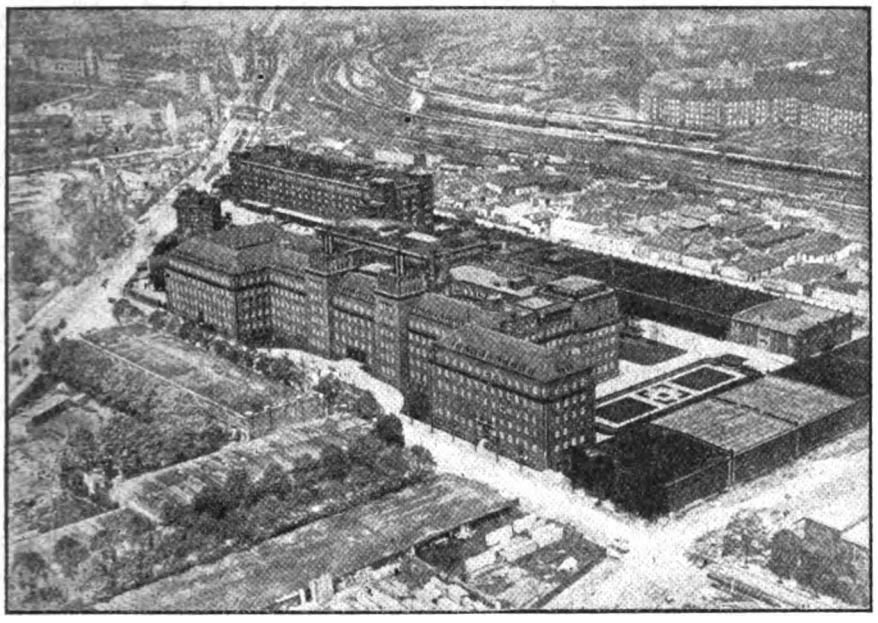

An aerial view of the vast building which houses Germany's Central Post Office in Berlin. In this building the Baird apparatus has been installed.

Bosch Magneto, the Zeiss Co., and Loewe Radio Co.—all names of eminence not only in Germany but the world over. It is satisfactory to know that these epoch-making arrangements were put into effect with every dispatch and with every desire to forward the main aim, which is to give Germany the best television system in the world.

Germany made further history in television by giving the Baird Company *permission to transmit for the first time in history a daily broadcast from 9–10 a.m., sometimes between 1 and 2 p.m., and after midnight.*

Televising to London.

Attempts have been made to pick up these pictures in London. At the time of writing, however, I do not know how successful this has been. (Probably it may be dealt with elsewhere in this magazine.) Strangely enough, the young Hungarian inventor Mihaly told me he had picked up the Baird transmissions on several occasions.

In view of my activity in Germany I have been somewhat out of touch with what has been happening in London. I had the opportunity, however, of flying over for a few days and although I find that the position is progressing normally so far as transmission in England is concerned, I must confess that it is impossible to refrain from comparing the wholeheartedness with which the German authorities have co-operated with us with the niggardly manner in which the British inventor has been treated in his own country. There is a good deal I could write on this matter even though "Peace has been declared" and "flags are unfurled" and "everything in the garden is rosy."

Writing from Berlin in a totally different atmosphere I cannot refrain from an expression of impatience with what has been happening in London. I should really like to tell the whole history; may be I shall one day.

Before this reaches print, however, I may be back in your midst—particularly if there is to be any further fighting!

Congratulations.

I cannot help congratulating the pioneers of television on the remarkable progress made, not only here in Germany, but in different parts of the world. I read with great interest in the last issue of TELEVISION of the happenings in other parts of the world. Surely it is the first time in history that such enterprise has been exercised on behalf of a big British undertaking.

In Germany they would be the first to encourage such endeavours, but old England is known everywhere as conservative and rather stick-in-the-muddish. Despite this incredible aloofness, television has come into its own! What remarkable endurance, what a miracle, what a chance for the historian to tell of this up-hill fight in

TELEVISION IN BERLIN.

This photograph was taken on the occasion of the Baird Company's first demonstrations of television transmission and reception in Berlin. Bottom row (left to right)—State Secretary, Dr. Bredow; Under-Secretary of State, Dr. Feyerabenet; Herr President Kruckow of the Post Office research department. Top row (left to right)—Mr. Sydney A. Moseley; Dr. Banneitz of the German Post Office; Managing Director of the Rundfunk Gesellschaft, Herr Giesecke; co-Chief Engineer Schäffer of the Rundfunk Gesellschaft; Commander Jacomb, Chief Engineer of the Baird Company; Capt. O. G. Hutchinson, Managing Director of the Baird Company; Dr. Reisser, co-Chief Engineer of the Rundfunk Gesellschaft.

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a country that is always calling out for efforts on behalf of its men and refuses to accept such service when it is offered. I frankly admit a sort of satisfaction that Germany should have been the first to broadcast television daily.

From the beginning, when Dr. Bredow, accompanied by his chief engineer, Dr. Reisser, came to London, one saw that here was a country that was go-ahead and was not going to permit personal jealousies, intrigues or red tape to interfere with progress. Since my stay in Germany I have come to understand the German people very well, and since science has no boundaries, I am well content. It is up to those readers who are disappointed that England has not been so enterprising to write to the new Postmaster-General and ask him what about it.

Auf Wiedersehen,

SYDNEY A. MOSELEY.

Phonovision Foretold.

PHONOVISION, the storing of televised scenes in records such as are used for the gramophone, was visualised by Mr. H. G. Wells in 1899. In his book, "The Sleeper Awakes," Mr. Wells pictures London in 2099. Books, as we know them, have disappeared, and instead there are pieces of apparatus which picture the story, and speak it at the same time.

Here is the description:

"The hero observed one entire side of the outer room was set with rows of peculiar double cylinders inscribed with green lettering on white that harmonised with the decorative scheme of the room, and in the centre of this side projected a little apparatus about a yard square and having a smooth white face to the room. A chair faced this. He had a transitory idea that these cylinders might be books, or a modern substitute for books, but at first it did not seem so.

* * *

"He puzzled over a peculiar cylinder for some time and replaced it. Then he turned to the square apparatus and examined that. He opened a sort of lid and found one of the double cylinders within, and on the upper edge a little stud like the stud of an electric bell. He pressed this and a rapid clicking began and ceased. He became aware of voices and music, and noticed a play of colour on the smooth front face. He suddenly realised what this might be and stepped back to regard it.

"On the flat surface was now a little picture very vividly coloured, and in this picture were figures that moved. Not only did they move, but they were conversing in clear small voices. It was exactly like reality viewed through an opera-glass and heard through a long tube. His interest was seized at once by the situation, which presented a man pacing up and down and vociferating angry things to a pretty but petulant woman. Both were in the picturesque costume that seemed so strange to Graham. 'I have worked,' said the man, 'but what have you been doing?'

"'Ah,' said Graham. He forgot everything else and sat down in the chair. Within five minutes he heard himself named, heard 'when the Sleeper awakes' used jestingly as a proverb for remote postponement, and passed himself by, a thing remote and incredible. But in a little while he knew those two people like intimate friends.

"At last the miniature drama came to an end and the square face of the apparatus was blank again."

* * *

Here, except that the gramophone disc has taken the place of the phonograph cylinder, is a description of what may well be looked for in the near future, thanks to the genius of Mr. J. L. Baird. The printed word will still be necessary for many things, but thrillers, shockers, and other inhabitants of the libraries will be scenarioed by the author and phonovised by the publisher.

So every house may be the home of a theatre.

E. P.

Gecophone Adjustable Reed Cone Movement.

The new Gecophone adjustable reed-cone movement, made by the General Electric Company, Ltd,, and retailing at the popular price of 15s., is now fitted with a cone anchoring attachment at no extra cost. This small addition simplifies the attachment of the cone diaphragm to the armature reed and will thus be greatly appreciated by constructors.

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Some Notes on Exploring Discs—and their Construction

By W. C. FOX

In the following article our contributor gives a few hints on the construction of scanning discs, and how to balance them when made. He also has some interesting suggestions to make concerning the thickness and weight of the sheet metal employed.

TELEVISION, probably more than any other invention of recent years, calls for a very wide knowledge of science and its application, for it is primarily a combination of several branches.

Not only does it demand an advanced knowledge of wireless, but optics, electrical engineering and mechanics all have their part to play. For this reason the "experts" who have condemned it have nearly always been wrong. Expert perhaps in their own particular line, they were quite at sea when going outside it.

In no particular has this been more patent than in the case of the exploring disc.

Despite the allurements of the inertia-less cathode ray and the work put in on it, the rotating disc does its job and has not burst as one expert predicted, or failed to go fast enough, as others declared.

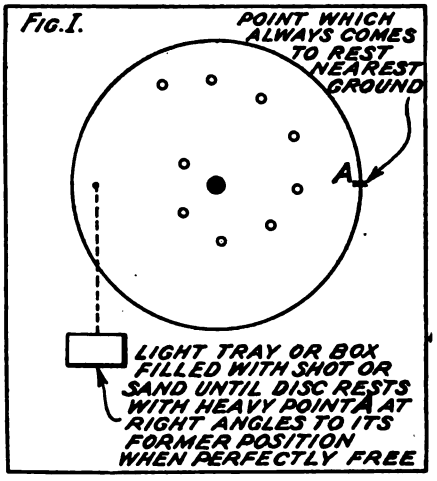
Simplicity of the Disc.

By reason of its very simplicity the disc succeeded where oscillating mirrors and other complicated devices failed. However, a good exploring disc is a very nice piece of workmanship and calls for some skill in its making.

For these reasons, these brief notes on making them are offered. As everyone knows, to move any object any distance requires force, even though the movement may be merely round and round a given point. The amount of force required, too, depends on the weight, or mass—whichever term is preferred—of the object moved. Similarly, as the speed of movement is increased more and more power is required, not in direct ratio, but of the order of four times the power for double the speed.

These considerations applied to the disc indicate that, unless finance is not a consideration (and finance in this case means ability to use as much power as is necessary), it is advisable to make it of as light a material as possible. Every increase in weight means a more powerful motor and greater current consumption.

In this connection it is surprising how little power an $\frac{1}{8}$ h.p. motor



gives. It will barely turn a cardboard disc three feet in diameter with twenty, two-inch, lenses, mounted on its periphery, the whole running on a three-foot length of $\frac{7}{8}$ in. shafting directly coupled to the motor shaft.

Therefore, when planning a disc, particularly if it is desired to run it up to speeds of 2,000 or so revolutions a minute, it should be made as light as possible, for at such a speed with a 2-ft. to 3-ft. disc about $\frac{1}{8}$ h.p. or more will be necessary.

Even with discs of smaller diameter there is nothing lost by making them of the lightest possible material, particularly where they are to be used in a receiver. On this service it is necessary for some form of synchronising device to control the disc speed, and a heavy rotating wheel takes more pulling up or accelerating than a lighter one. With a heavy disc the synchronising device, whether controlled by hand or by some other means, will have to "hunt" for a much longer period, and there will be more difficulty in finding the exact speed, than with a light disc, which will enable the motor to give very prompt response to any speed control.

Aluminium Best.

With regard to a suitable material, very thin aluminium sheet or untinned thin steel sheet known as "taggart" are suitable. They are easily cut, and have sufficient strength to stay flat when at rest. For discs up to about 18 inches in diameter black paper or thin celluloid can be used. When running centrifugal force will make them lay out quite flat. If nothing else is available, ordinary stout brown paper or drawing paper blacked with Indian ink where the holes come can be used.

Making one's disc of the lightest possible material is only half the battle. There is next the very important question of balance to be considered, i.e., the equal distribution of the weight of the disc, armature and commutator of the motor, etc., about the centre of rotation. This may seem a trifling point, but those who have followed racing motoring will know how very careful all successful motorists are to balance everything that rotates on a racing car. Even the tyre valves and the joint in the inner tubes on the road wheels are balanced. Or again, in aeroplane practice rotary engines are most carefully balanced, and an engine that shows even 1/64 inch wobble about its centre when running is returned to the shops to be re-balanced.

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While such a high degree of balance in an exploring disc may not be essential, the nearer one can get it to perfection the better, for at speed it plays an important part in the results secured. A disc much out of balance will not run at a steady speed or respond evenly and regularly

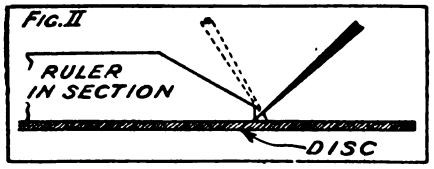


Fig. 2.
The solid and dotted outlines show two extreme positions of the scriber which are possible when marking out.

to any desired increase or slowing up that may be asked for.

Testing for Balance.

Having made the disc and mounted it on the motor shaft, it can be tested for balance by removing the brushes from the motor to get rid of their friction, and spinning the whole assembly. It will come to rest with some point on the edge of the disc nearest the ground. If during a succession of spinnings the same point on the disc always stops when nearest the ground, that part of the disc is heaviest, and therefore out of balance. If the disc is pronouncedly heavy at that point, it will be quickest to weigh it and remove or add metal accordingly

The weighing process is done as follows, and is illustrated in Fig. 1.

Opposite the point which always comes to rest nearest the ground (marked *A* in the diagram) and about half way between the centre of the disc and its edge is drilled a small hole.

Through this a piece of string or thread carrying a small pan or box is fixed, either with a knot or by tying a nail or piece of wire in it.

Then sand, shot, or even tintacks are dropped into the pan until it just, and *only* just, pulls the disc up to the position indicated in Fig. 1.

The quantity of material that has been put into the pan, not forgetting the weight of the pan and string, will give one a guide as to whether it is best to drill holes in the heavy portion of the disc wherever convenient near point *A*, or add weight on the opposite side of the disc in the region of the small hole drilled.

Correcting Lack of Balance.

When this initial correction has been carried out, the disc is spun again, and if it is still found to be heavy at one point further correcting is done by removing or adding weight until when spun by hand the disc never comes to rest over a series of times with the same point nearest the ground.

If a disc is but slightly heavy it is best to correct it by filing a trifle off its edge on the heavy side, or if this is not practicable, add weight by putting small blobs of sealing wax or a small nut and bolt on the light side. In any case, go carefully and a little at a time. Furthermore, having balanced a disc on a motor shaft *don't* remove it unless you can replace it *absolutely* in the same position, because in all probability you have balanced inequalities in the armature of the motor and its commutator assembly, and to replace the disc in a position different to its original one will accentuate these.

The success of any disc, however well balanced and synchronised, depends entirely on the way it has been marked out and made. Carelessness in this operation will turn a good television transmission into a featureless blob.

Marking Out.

Marking out is a tedious job calling for care and the observation of one or two precautions, but it is not beyond the skill of any careful amateur.

Having selected the material and marked the centre of the disc, the next point, if metal is being used, is to mark out the circle of its full diameter. This will be scratched on the surface of the metal. Inside it will come the circles locating the radial position of the holes. These should be marked out with the utmost care as any irregularities in their position will cause white lines or black bands in the received image.

This part of the work is best done with a large firm pair of dividers. It is a decided advantage to have them with hinged legs, which can be bent to stand at right angles to the surface of the work, even when marking out the largest circles. Better than a large pair of dividers is a pair of trammels of heavy construction, with a metal beam.

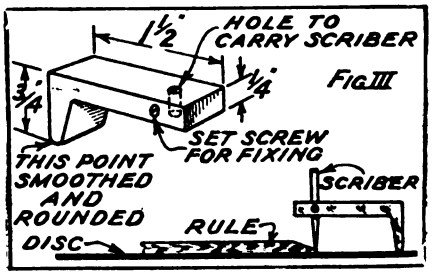
Having marked out the circles fixing the radial position of the holes the next point is to draw the radial lines which locate their circumferential position.

It is here that the greatest inaccuracies are likely to occur. For dividing the circle, the largest protractor that one can secure is the best, and it can be taken as a maxim that the larger the protractor the smaller will be the error. The next point to watch is in ruling the lines. However good the ruler and scriber it is possible to rule parallel lines without moving the ruler, simply by reason of the thickness of the edge of the ruler.

Parallax Error.

Figure 2 shows a section, enlarged, of a ruler and scriber illustrative of this point. If you doubt your ability to hold the scriber invariably in the same position when marking a line, t is best to make a simple bridge form of carrier that will hold it in one plane at right angles to the surface of the metal. Figure 3 shows such a bridge made out of any suitable piece of metal bar that may be handy. Approximate dimensions are given. In use, the bar is kept as nearly as possible at right angles to the edge of the rule with the scriber up against the edge. Although one can tilt the scriber backwards and forwards *parallel* with the edge of the rule, it cannot be inclined to or from it (see Fig. 2), which causes the inaccuracies in marking out.

On cutting out a disc, particularly if it is a large one, *don't* try to follow the circle all round with one continuous cut. You will, even in the



thinnest metal, get tied up and probably distort the disc, not to mention the chance of cutting your fingers.

Up to this point it has been assumed that it is known how to mark out a disc for any particular given ratio and number of scanning holes.

For the benefit of those who are just starting to explore the fascinating field of television, the following brief details are given of how to arrive at marking out measurements of a disc from supplied data.

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The diameter of a disc controls the size of the picture, irrespective of all other considerations, and the disc need not necessarily be of the same diameter as that in use at the transmitting station. On the other hand the size of hole used for scanning determines the diameter of the disc for any given set of details.

A Hypothetical Specification.

In all probability, some such statement as the following will be given to describe a disc: "It is 60 scanning lines wide and 70 units high."

Such a statement means, first, that a disc of 60 holes is used and that the picture is $1\frac{1}{6}$ times as high as it is wide.

To mark out a disc from such information, one considers first the number of scanning lines wide and the smallest hole, square preferably, one can cut in the material decided on for the disc.

Suppose 1/10 of an inch is decided on as the size of the hole, then, as every one of the scanning lines has to just touch its neighbour, sixty 1/10ths of an inch placed side by side make a line 6 in. in length, which will be the width of the picture. As it is 70 units high, it will be 7 in. high.

The next point is to arrive at the diameter of disc which will give a picture 7 in. high by 6 in. wide.

As there are 60 scanning holes they will have to be placed on 60 equally spaced radii of some circle.

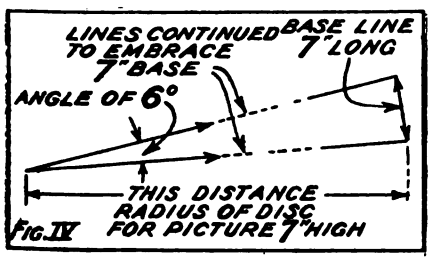

FIG. IV

On a large sheet of paper, towards one side, draw a straight line, and with this as base, draw another line at an angle of 6 degrees to it. Six degrees is 1/60 of 360 degrees, making the complete circle. These two lines will have to be continued to such a distance that an isosceles triangle of 7 in. base can be made, the angle at the apex being 6 degrees. The length of either of the long sides then gives the radius of a disc which will give a picture of the ratio being considered. For constructional purposes the radius would have to be a little greater, because it is not desirable for a hole to be on the extreme edge of a disc. This is shown diagrammatically in Fig. 4.

Determining Disc Dimensions.

For an angle of 6 degrees a very large disc would be required to give a picture 7 in. high.

Alternatively, if the diameter of disc that can be used is fixed, one can determine the other details to conform to the 60 scanning lines wide by 70 units high as follows:

Assuming the disc is $24\frac{1}{2}$ inches in diameter, the angle of 6 degrees is drawn on a sheet of paper, each line this time being made 12 inches in length, $\frac{1}{4}$ in. less than the radius, for the reason already given above. Two such lines forming an isosceles triangle with an apex angle of 6 degrees require a base of $1\frac{3}{32}$ in.

This distance of $1\frac{3}{32}$ is therefore the height of the picture 70 units high, and has to be divided into 70 equal parts, which works out to ·02 in. approximately as the diameter of the holes.

Drilling Small Holes.

Such a sized hole, although small, is quite easily drilled. Morse twist drills are best for such a job, and can be purchased as small as $\frac{1}{64}$ in. in diameter. Use the smallest and lightest brace obtainable and don't press hard on it. Very light pressure and high speed will drill the hole far more quickly than pressure which nearly bends the drill, coupled with slow speed. If in such a case metal of any thickness is being used for a disc, it will pay to countersink the hole each side of the disc, leaving only the smallest thickness of metal carrying the actual hole.

In any case thick metal for a disc is a mistake, because, quite apart from the load it will put on the motor and the expense of driving it, it will not permit one to view the image from as wide an angle as will a very thin disc.

This is illustrated diagrammatically in Fig. 5, where equal sized holes in thin and thick plates are shown.

The dotted lines indicate the extreme width over which light passing through the hole can be seen.

When making a disc it is best to do the whole of the marking out first, then drill, cut to diameter, and cut out the necessary holes in the centre for mounting purposes. Unwanted metal in the centre of the disc is next removed, and finally the disc is balanced on its shaft.

It may appear from what has been said that making a disc is a long and tedious process. It is not so really, but if one does not feel like taking care, it is merely a question of balancing one's ability to put up

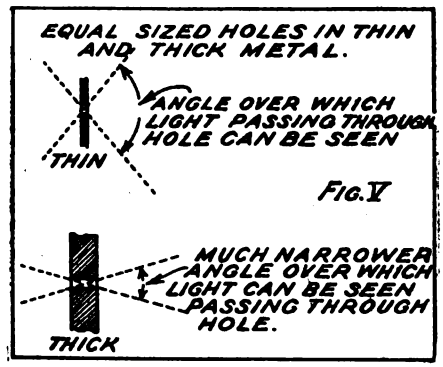

FIG. V

with a faulty reception of a good image against one's inclination to use a little care and thought in doing well the job that plays a most important part in television reception. Your reception depends finally on you.

Television and the Empire.

Mr. W. M. Hughes, the former Australia Premier, has just published a new book entitled "The Splendid Adventure" (Ernest Benn, 21s.). On page 277 of this book Mr, Hughes sums up the importance to the outposts of our Empire of rapid communication, and his words reveal the fact that he is by no means unacquainted with the vast possibilities of television. The passage in question reads as follows:—

"Wireless is to the people of the Empire a veritable gift from the gods, and daily new and wonderful developments are manifested; broadcasting and direct beam wireless telegraphy and telephony, which within a very short period will be operating between Britain and the Dominions, and later, television will bring the peoples of a world-Empire as intimately together as the inhabitants of Britain itself were twenty years ago."

"CAN FREQUENCY AND PHASE-CHANGE MODULATION REDUCE INTERFERENCE?"

Read this most interesting article by J. H. OWEN HARRIES, A.M.I.R.E., in our next issue.

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LIVING PICTURES

By CHARLES JONES

IT is my good fortune to have business among farmers. They are a good race of men, deriving mostly from hereditary stock, and even now somewhat aloof from the scurry of events. They escape all the fussy regimen and purposeless hurry of a "well-ordered life," and having shouldered the whole burden of Adam's curse, retain also some fragrant memories and an occasional glimpse of Paradise.

As a result they are terribly conservative. It takes more than the scheduled results of agricultural college experiments to convince them that a balanced, synthetic fertiliser can make the ear that was forty-fold bring forth in its turn, grain an hundred-fold. They trust the bounty of the mother earth they know, rather than the chemical factory they wot not of.

"Because They Cannot See."

Perhaps it is because they cannot *see* the good work of the colleges and the actual results of scientific tillage, that they refuse to sink money in a grey powder, which, they are persuaded, would heal the sick field, and like a magic potion, add tons to the crop. Even fairy godmothers are unconvincing, if they stop short of demonstration.

Be that as it may, in early June (just before turnip sowing) I mounted my bike, and rode away, out of the village, to the farmsteads among the hills, armed with figures and invincible arguments.

Of the glory of the season; of the bright aspect of the plaided fields like crazy mantles laid upon the slopes; of the plumed copses, and monstrous-patterned sky, I must reck nothing here, except to say how these things make for gladness, and sweep away idle doubts, if one has them, like the vision of a visible god. Where men raise a roof they often exclude much that is assured and sane, and they argue greatly as though life were full of menace. But the open spaces, swept by the breath of Heaven, are not a challenge to the mind, but an embrace. Men of parts are bred in them, under the ægis of friendly skies.

Towards the end of the day I rode into the rickyard of the last farm; a farm tucked in the outermost ridge of the downs, like a babe's head in the folds of a great counterpane, and giving out upon the sea.

I dismounted amongst a crowd of heedless hens, with no idea of one-way traffic, and snuffed the sea-fume and the pungency of new-cut hay in one spicy breath. I glanced right and left, and at the second glance saw a freckled boy sitting astride the high ridge of a hay-stack, with withy thongs in his hand. He looked at me as a country boy does, mutely, and smiling. When I made no remark, he stabbed a thong deftly in the straw and bound down a wisp of wind-torn thatch.

"Hey!" I called, "Mr. Darke at home?"

The boy flung his leg over the rick, and slid quickly down the high-pitched side. He shot from the edge, eight feet above ground, at an appalling speed, and landed on his toes with marvellous precision, between two scared hens. Laughing with a gurgling sound, he pushed a school cap back on his head, and said:

"I think he's in house. I'll see."

The Joy of Youth.

He led the way through the yard to the farmhouse. It was a joy to follow him, to watch the jacket crinkling on his muscular young back, and the easy swing of his scratched legs, still in schoolboy shorts. He dived into the house, and ran back in the space of a breath swinging his cap in his hand.

"Dad can see you. . . . in yonder, Sir." He pointed through the dark door.

In a moment he was gone. But I hesitated at the door, strangely

A general view of the Baird Company's research laboratory in North London.

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chastened, just for a moment of time. His voice was young and clear, his eyes healthy and clean. But beyond that, beyond the attributes of innocence which make their own appeal to the heart, his face had a radiance not of light or health, something of inexpressible purity for all that it was a freckled face with hayseeds caught in the eyebrows, and no little mischief betided in the eyes. But why bother with the indescribable ?

My business with the farmer was done in half an hour. To clinch it, he laid a cheque on the closed lid of a pianoforte in the dim farm parlour. As I picked up the cheque and folded it I glanced up, and saw on the wall, not one, but a dozen certificates to one Ernest Darke, for proficiency in pianoforte playing, for harmony and counterpoint, of several grades, rounded off with an A.R.A.M. Perhaps I looked too long.

Repressed Pride.

" My boy," said the farmer, with the uncertain tremor of repressed pride.

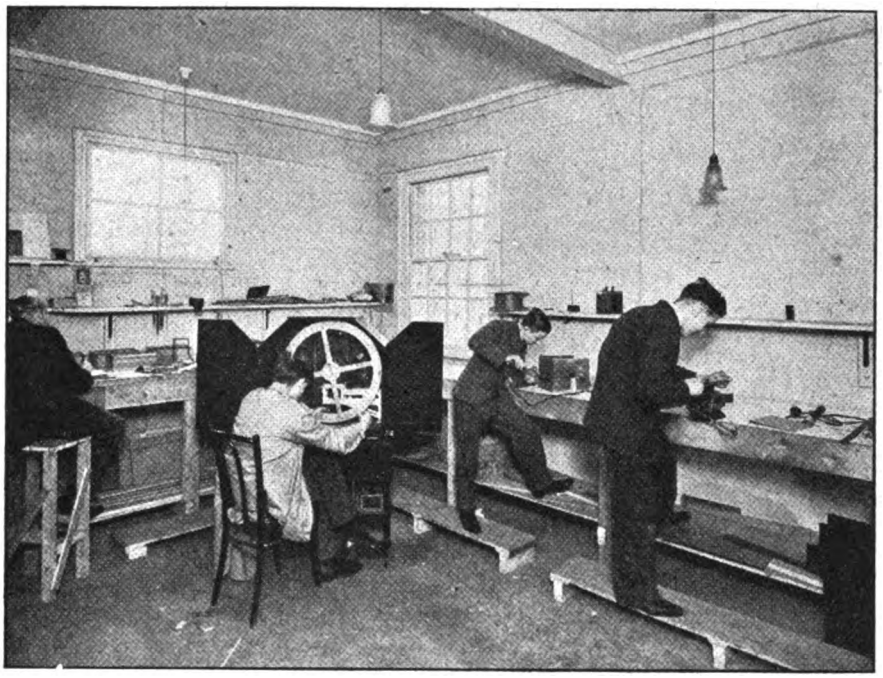
" What ! The lad outside, who showed me in ? "

" No ! Not that young rascal," answered Darke with a laugh. " He couldn't play the bones. He's all for the pencil, that one."

" It's jolly interesting," I said, for lack of anything more explicit to say.

" Like to see some of the young scamp's playthings ? " he asked. As I murmured vaguely he brought a brown paper portfolio from a side table and laid it before me. On the outside, in illuminated printing, I read, " Ronald Darke. His Drawings." I turned over the cover, and on top of the sheet found pencil drawings of a daisy, perhaps a hundred. There was a tight-folded daisy bud like a lump of knotted twine : a daisy with petals shot out like a dozen tongues : a daisy just spreading, with a look of dew on it : a daisy like a spread parasol, gulping sunlight : a daisy with bent, afternoon head on a straight stalk : a daisy, sagging, twisted towards an invisible sinking sun, with languorous leaves and curving stem, full-fed and tired. Not just a daisy, but a daisy living its life, intimate and complete.

I searched the many sheets, some of which were better and some worse. There were a hundred studies of birds. A snail, in all his score of attitudes : at home and snug, or with palpy foot outspread and exploring antennae,



Assembling and testing Television Receivers at the Baird Company's laboratories.

rounding a perilous thorn with amazing elasticity, or feasting at ease upon a veined leaf. Further in there were little landscapes, an attempt or two in colour, and endless studies of waves breaking upon a sandy shore. There were designs and illustrations, but limited in scope.

Profound Observation.

I looked up at the farmer, who was twisting his moustache and grinning.

" Some kiddie, this," I said, with conviction. The drawings had that apt and sure quality of line which can only be won by profound observation, and an untiring struggle against the natural inertia of nerve and flesh. There was the patience and urge of love behind them.

" Never get his living at that," commented Farmer Darke, whose eyes nevertheless showed he had not missed the travail of his boy's spirit.

" No," said I, " but he'll live on it."

With a mute understanding on this somewhat sententious point we parted, and I made my way out through the rickyard thinking about the brace of boys in the farmer's household, each with his separate star, so far removed from the point of orientation of his forefathers. I wondered over the quaint and almost irrelevant way in which Nature throws up her shrewder and more sensitive humanities ; those mutations of the intellect which she flings up in the race as inconsequently as she builds flowers from the foulings of the earth.

I had a glimpse of the tall hayrick, and noticed that the thatch was rebonded. The boy was on the gate swinging his legs. He thrust the weight of his body forward, and opened it for me.

" You're fond of Art ? " I asked, as I passed through.

He stared at me uncomprehendingly.

" Fond of drawing ? " I explained, feeling shy under the bright gaze of a boy on whom no thin, wordy deception can be practised.

" How d'you know, Sir ? " he asked.

" Your father showed me. . . ."

" Oh that ! " he replied. " That's only practice."

" Looking for bigger things ? "

" Some day."

" What About Television ? "

" What about television ? That will open your eyes when it comes your way."

He was walking beside me now, as I pushed my bike over a field path.

" I think my eyes are open," he said with a boy's fine confidence. " But what is television ? "

" Television ? Oh, the science of sending living pictures by wireless."

He looked full at me.

(*Continued on page* 258.)

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The Story of Chemistry

Part X

Isotopes

By W. F. F. SHEARCROFT, B.Sc., A.I.C.

WE have seen that Prout's brilliant speculation, that all the elements were composed of aggregates of hydrogen atoms, had to be abandoned owing to the experimental evidence against it. The atomic weights of certain elements were so definitely fractional, taking into consideration all possible experimental errors. Still, the idea persisted, and through the following century we see attempts to reconcile facts with theories.

One interesting speculation was that, during the hurly-burly of atomic life, some of the atoms became somewhat "worn out," and thus accounted for their weights being fractional and not whole numbers. It has to be remembered that in all the chemical methods of measuring atomic-weights, specimens of the element concerned, which contain many, many millions of atoms, have to be used. The results are, therefore, *average* values. There is always the possibility of variation in the individual atoms, although, as the average values are constant, there must be order in the variation, which could hardly be postulated for "worn out" atoms.

Chemical Families.

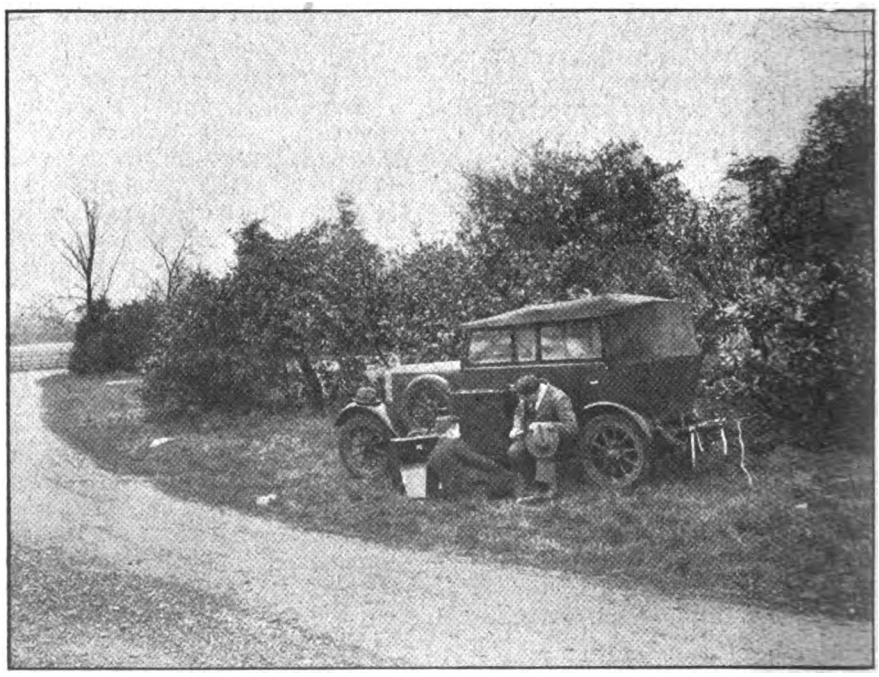
We have previously mentioned that the chemical elements may be grouped into families which show similarity in properties. Sometimes this similarity is very close indeed. With the group of elements known as the *rare earths* it is so close that considerable experimental difficulty occurs in attempts to separate the elements or their compound.

When dealing with the radioactive elements still closer likenesses were found. Thus an element ionium was known, and its compounds when mixed with similar ones of thorium were found to resist all attempts to separate them. By all the chemical tests known, ionium and thorium were identical. They differed, however, in their radioactive properties, in such a way as to make it perfectly clear that they were two distinct elements. Chemically they were identical.

Identical Elements which are Different!

Here is a new conception—two identical elements which were different! It is only possible to assume that the difference is due to differences in internal structure. This may concern the planetary electrons or the nucleus, a mixture of electrons and protons. So alike are the chemical properties of these elements that it is difficult to see how the outer arrangement of planetary electrons can be altered, without such alteration being manifested by chemical difference. This suggests that the real difference lies in difference of nucleus.

Now the proton is the part of the atom which is weighty. An electron has a mass of about 1/1845 of that of a hydrogen atom, and so only contributes a very small share to the weight of the atom, even in those atoms which have many electrons. A



PORTABLE TELEVISION!

The above illustration shows a Baird portable televisor receiver (resting on running board) undergoing tests in the country. The broadcast television impulses are picked up by a portable wireless receiver, the output of which feeds the portable televisor.

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change in the nucleus would entail, therefore, a change in the atomic weight. In the case of ionium and thorium, therefore, we seem to have two identical elements with different atomic weights.

Isotopes.

Further work with radioactive elements revealed other similar cases, and such elements were called *isotopes*. For some time, isotopes were only known among the elements with high atomic weights which were radioactive.

The next step in the process came from another line of research. When a radioactive substance disintegrates, we have explained that it shoots out certain particles. In some cases the particles are positively charged and have been identified as helium atoms bearing positive charges; that is, helium atoms which have lost some of their planetary electrons. In some cases the radioactive atoms emit electrons. This will leave a particle bearing a positive charge.

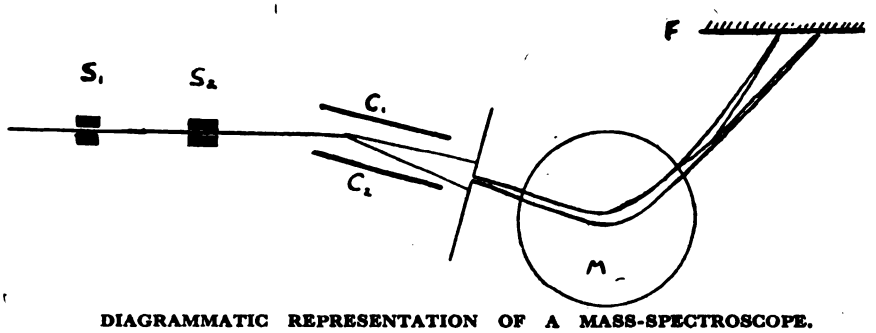
Canal Rays.

Goldstein, in 1886, noted the existence of what he called "canal rays" when an electrical discharge was passed through gasses at low pressure. Wien, in 1898, showed that these rays could be deflected by a magnetic field, and J. J. Thompson carried out a detailed study of such rays, called them *positive rays*, and showed that they were positively charged particles. They are produced by the process which we now call ionisation. In gases, under low pressures and the influence of an electrical field of about 50,000 volts, electrons are torn off from the atoms, and positively charged residues are left.

Thomson investigated the charges and the mass of these particles by means of a method known as the "parabola method." The streams of positive particles were passed along a very narrow tube, and the very narrow beam so obtained was acted upon by electrical and magnetic fields, which deflect the rays from their paths. The deflection depends upon the mass and the velocity of the particles, and Thomson obtained a photographic record, shaped like a parabola, from which he was able to make the necessary calculations of the mass of the particles.

The Mass Spectroscope.

A marked step in advance was made by Aston, who considerably improved the method of positive ray analysis. He invented the mass spectroscope. The positive rays to be investigated are passed through two very narrow slits, and passed between two charged plates, which spread them out much in the same way that a prism of glass spreads out a narrow beam of light. Part of this electrical spectrum is then passed through a strong magnetic field, which causes a further deflection, and finally results in the bringing to a focus of all the particles having the same mass. These are made to impinge on a photographic plate and make a record upon it.



DIAGRAMMATIC REPRESENTATION OF A MASS-SPECTROSCOPE.
S_1 S_2 Slits. C_1 C_2 Charged Plates.
M Magnetic Field. F Photographic Plate.

If a mixture of particles of varying mass is passed through the instrument, then the particles will be sorted out and caused to make records at different points on the plate, according to their mass. If the atoms of an element are ionised, that is, converted into positive particles, then if they are all of the same weight they will make but one record on the plate, if of varying weight then they will indicate this fact when they are sorted out. By choosing some element as a unit, comparisons of the mass of the atoms can be found.

From a study of such mass spectrographs Aston was able to show that the lighter elements not known to be radioactive, also exist as isotopes, and that the weights of the atoms were always whole numbers. The fractional values obtained by the chemical methods were due to the mixture of different atoms, which were dealt with in bulk. Thus, for example, Aston found that the element chlorine was a mixture of atoms whose weights were 35 and 37, with a probable one, weighing 39. Further, he was able to estimate the proportions of these atoms in a sample of the element and his results showed that the mixture would have an average atomic weight of 35.46, the result which is obtained by the chemical determinations.

Return to Simplicity.

We now know the weights of the atoms, as distinct from the chemical atomic weights. We know that an element apparently homogenous, as far as all our chemical tests can indicate, may consist of mixtures of atoms varying in weight, but having the same chemical properties, that is, consisting of isotopes. Further, it has been demonstrated that the weights of the atoms are all *whole numbers*, and thus the original objection to Prout's hypothesis is removed, and we may return, with some slight modifications to be noted later, to the fascination of simplicity—a universe made up of one primordial substance, hydrogen. Certainly we no longer fancy the atoms of the elements as simple hydrogen atoms packed together. There is more than simple packing in it.

Experiment has demonstrated the possibility and the existence of isotopes, and it remains to explain the theoretical aspects of these interesting discoveries. Possibly a concrete example will help. Lithium is an element found in nature, which has a definite set of chemical and physical properties, by which we recognise it. Its atomic weight determined by chemical means is 6·94. This element, as found naturally, Aston has shown to consist of two isotopes, the weight of the atoms of which are 6 and 7. They are mixed in a proportion such that

(*Continued on page* 258.)

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PHOTO-ELECTRIC CURRENTS IN A VACUUM

By H. WOLFSON.

Readers who have been following Mr. Wolfson's series of articles on the photo-electric effect, and various types of photo-electric cells, will recall that last month he dealt with "Photo-electric Currents in Gases." This month he goes further back and outlines the various phenomena which led early observers to recognise photo-electric effects. These effects were first observed in free air. Later, experiments led to the production of the effects in a vacuum.

LAST month we considered in detail the various factors affecting the emission of photo-electrons when the sensitive substance was placed in a vessel containing a gas. We saw how an alteration of gas pressure, and of the nature of the gas exerted a marked influence on the photo-electric current which could be obtained from the cell.

In this article we have a number of equally important problems which arise when the cell is of the vacuum type. Many cells at present in use are evacuated, in preference to being gasfilled, and for certain purposes are preferable to the latter type, though they give a much smaller current than the gasfilled types.

We shall consider first the work which led up to the investigation of the emission of photo-electrons in a vacuum, since it was most natural to work with the substance in the air, as did some of the earlier workers.

Method Adopted.

Perhaps one of the most valuable lessons to be drawn from the present article is the *method* which was adopted by each different worker, and it is possible to trace a gradual refinement of both method and apparatus, without which many anomalies would have remained unexplained.

Hertz's apparatus was definitely of the cruder kind, yet it served its purpose admirably in that it led up, quite accidentally, to the discovery of photo-electricity. He used two sparks, *A* (see Fig. 1), serving to excite the primary oscillation, was obtained from the ordinary discharge of an induction coil, while *B*, which served to measure the action set up in the secondary circuit, belonged to the induced secondary oscillation. The spark *B* could be enclosed in a light-tight case at will. When the spark *B* was so screened its length was less than in the unscreened condition.

A convenient arrangement of apparatus for the investigation consists of two induction coils *A* and *B*, Fig. 1, arranged with their primaries

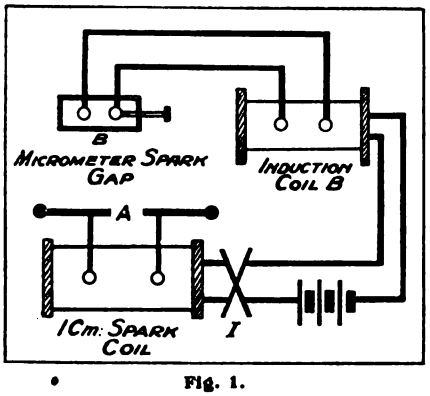

Fig. 1.

Herts's apparatus, demonstrating the photo-electric effect.

in series with the common battery, and worked by the common interruptor, *I*. The coil *A* gives a spark about 1 cm. long, while the length of spark *B* is only 1 mm.

The spark gap at *B*, which is fitted with micrometer adjustment, is arranged of such a length that sparks can just pass when it is subjected to the action of the spark *A*. If a plate of metal or of glass is interposed between the two parallel gaps, the spark at *B* at once ceases, and reappears as soon as the plate is removed. The action increases as the distance between the sparks is diminished.

Effect of Oxidization.

Hertz also found that the effect was either diminished, or else entirely absent, when the terminals became dull, tarnished or corroded. The effect was found to be transmitted in straight lines, by the usual type of experiment with slits and screens. A number of substances both solid, liquid and gaseous, were found to hinder or prevent the action, and by combining all the evidence quoted and carrying out further experiments dealing with the reflection and refraction of the light from the longer spark, it was possible to prove conclusively that the active portion of the light belongs to this ultra-violet portion of the spectrum.

Confirmation of this hypothesis was sought by the early experimenters, who employed a number of different light sources to bring about the effect. The electric arc, which is the richest in ultra-violet light, was capable of producing the effect up to a distance of four metres, and magnesium ribbon produced quite an appreciable effect All the experiments as to the propagation, absorption, reflection, refraction, etc., were repeated, and the results were in strict agreement with those already obtained when working with a powerful spark as the source of illumination.

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Hertz had recorded the fact that the action of ultra-violet light on the smaller or passive spark seemed to take place near the poles, and more especially near to the negative pole or cathode. Wiedemann and Ebert investigated the point more completely, and found that the true seat of the action was definitely the cathode.

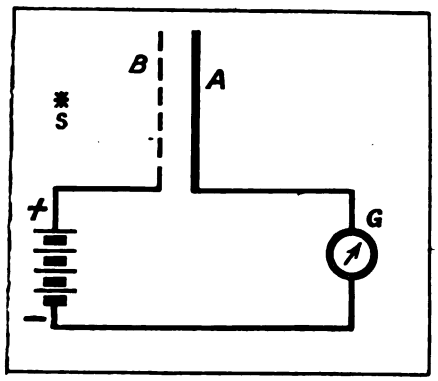

Fig. 2.
Stoletow's arrangement for demonstrating that a metal plate emits electrons under the influence of light.

Chief among these early investigators was Hallwachs, who sought for other phenomena of a similar nature by which he could explain the results of Hertz, and in this way was led to examine the action of light on electrostatically charged bodies. A polished zinc plate was connected to a sensitive electroscope, and was carefully charged, in one set of experiments negatively, and in another, positively.

Hallwachs' Experiments.

The plate was then illuminated by light from an arc lamp. In the case of the negatively charged plate, the leaves of the electroscope began to collapse as soon as the illumination was allowed to fall on the zinc plate, but in the other case, no effect was produced. The same results were obtained by using burning magnesium ribbon as the source of light, and Hallwachs concluded that the effect was due principally to ultra-violet rays, which conclusion had been reached previously by Hertz.

The light was shown to have no action on the surrounding medium, in this case air, and the effect was traced to the metal surface. This result was confirmed by the discovery that the activity of the metal plate was nearly fifty times as great when the plate was freshly polished as when it was old, or tarnished. Experiments carried out with a view to determining the relative activities of various metals showed that aluminium was more active than zinc, while iron was less active than either of these metals.

Conclusive Proofs.

Hallwachs concluded that when a negatively charged metal plate is illuminated, negatively charged particles travel away from it, following the lines of force of the applied electric field. He also stated that "metal plates become electrostatically charged when irradiated with the electric light," and this view was confirmed by his later experiments.

He suspended a metal plate inside a rusty iron cylinder, and connected the plate to a Hankel electrometer. The contact potential against the plates to be examined was always negative, and it is only in this case that a rise of potential could be explained without any doubt, since, had the plate been negative to the case, a rise of negative potential would have occurred, as a result of the transport of negative electricity by the illumination.

With the plate positive, however, an increase of potential could only be explained by saying that positive electricity was produced on the plate. This production of a positive electrification is consequent upon the removal of electrons, or particles of negative electricity, from the plate, which disturbs the neutrality of the atoms of which it is composed, leaving them with a nett positive charge.

Experiments with a number of metals gave this same result, and it is interesting to note that the potential produced in the case of zinc was well over one volt, while brass gave one volt, and aluminium half a volt.

Stoletow and Righi.

Hallwachs' experiments had been followed with great interest by a number of other workers, and Stoletow and Righi, in 1888, working independently, devised a novel method of studying the discharge of bodies previously charged to a low potential. Both used the idea of a metallic grating or gauze placed a few millimetres from, and parallel to, the metal plate with which they were experimenting.

Stoletow's apparatus is shown diagrammatically in Fig. 2. *A* is a metal plate which is connected in series with a very sensitive high-resistance galvanometer, a battery and the gauze screen *B*. The grating is made positive to the plate. On illuminating the plate, the galvanometer indicates a current, but if the connections are changed round, no deflection is produced on the galvanometer. This, then, would suggest and confirm the view that the plate emits electrons under the influence of light.

Elementary Photo Cell.

The later editions of Stoletow's experiments employ a quadrant electrometer in place of the galvanometer. Stoletow constructed what might be described as an elementary type of photo-electric cell, which would cause an electric current to flow in an external circuit, by allowing ultra-violet light to pass through the openings in a perforated plate, and then fall upon a second plate. The active plate must be made of the less electro-positive metal, in order that the contact potential difference can drive negative electricity from the active illuminated plate to the perforated one.

Righi placed a vertical disc of metal *A* (Fig. 3), not far from the parallel gauze net *B*, arranged so as to be connected to the opposite pairs of quadrants of the electrometer *M*, that pair which is connected to *B* being earthed. *A* can

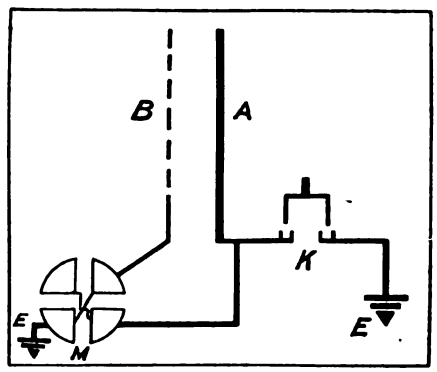

Fig. 3.
Righi's Apparatus.

also be earthed by means of a plug switch *K*. After momentarily earthing *A*, the illumination is turned on, and a deflection is obtained on the the electrometer, this reaches its maximum in a time which is less the nearer the source of light, and the

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larger the metal surfaces. *A* was made of zinc, and *B* of brass. The arrangement of plates may be termed a simple photo-electric cell.

Elster and Geitel, in 1889, only two years after Hertz's original discovery, showed that electro-positive bodies, like the alkali metals, sodium, potassium, rubidium, etc., exhibit photo-electric activity when

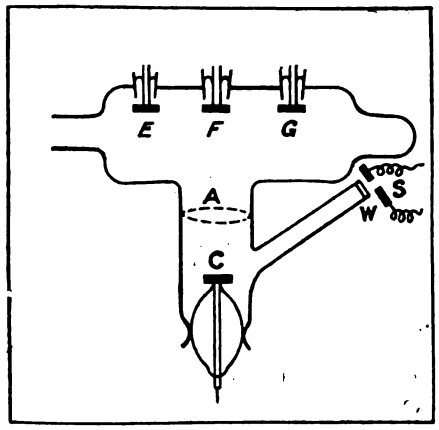

Fig. 4.
Merritt and Stewart's apparatus for the identification of photo-electric rays.

exposed to light of the visible spectrum. The most electro-positive of the alkali metals will lose a negative charge when the source of light is a glass rod heated to redness. Freshly prepared surfaces of less electro-positive metals, such as zinc and aluminium, exhibit an activity much smaller, it is true, when exposed to bright sunlight.

An Enclosed Cell.

In 1904, Hallwachs made the discovery that a plate coated with black copper oxide, preserved in an airtight chamber, showed a photo-electric activity which was remarkably constant over long periods of time. He actually used this type of cell in photometry, to compare the intensity of two sources of light.

Later Elster and Geitel suggested the use of potassium cells filled with some inert gas, such as argon, for ultra-violet photometry.

In 1890, Elster and Geitel made the important discovery that the application of a transverse magnetic field diminishes the photo-electric current, if the cell contains inert gas at a low pressure. These results suggest that photo-electric carriers in a vacuum or low pressure inert gas are identical with cathode rays, and this conclusion, fully substantiated by experiment, gave for the first time a clear understanding of the nature of the corpuscles which act as carriers in photo-electric phenomena, and which we term photo-electrons.

Photo-electric and Cathode Rays.

The question of the identity of photo-electric "rays" and cathode rays is of such far-reaching importance that a closer study of the work which was done by the earlier workers should not be overlooked, although we are so accustomed to taking it for granted, that we are apt to lose sight of the fact that it did not immediately occur to the pioneers, nor was it accepted without most rigorous experimental proof.

In 1889, J. J. Thomson carried out measurements of the ratio of the charge carried by the particles to the mass of the particles. Within the usual limits of experimental error, the results for the value of the ratio e/m were in good agreement with those already determined for cathode ray particles. The value of the charge of the photo-electric particles was found to be the unit charge already known from measurements in connection with electrolysis.

The experiments of Lenard and of Merritt and of Stewart are of great interest and importance, and a short account of the method employed by the latter investigators is representative of the work which was done in this connection. The apparatus employed by them is illustrated in Fig. 4.

Merritt and Stewart's Experiments.

The cathode *C* is a zinc plate, which is maintained at a potential of 1000 volts by means of a dry pile. This is placed at the bottom of the tube, while the anode, *A*, is an aluminium ring. The side tube is fitted with a quartz window *W*, through which light from a spark between zinc terminals can pass and illuminate the cathode. The three electrodes, *E*, *F*, *G*, are fixed at the top of the tube, and the rate of change of potential at each of these electrodes was measured by means of a Kelvin quadrant electrometer.

When there was no applied magnetic field, the instruments showed that the middle electrode, *F*, received a negative charge. If the applied magnetic field was at right angles to the plane of the apparatus as shown, and in a direction away from the observer, the negative charge was received by the right hand electrode *G*, either wholly or in part, according to the strength of the field. On reversing the field, the bulk of the charge appeared at *E*, the middle electrode receiving the same fraction of the total charge as in the previous case, this fraction depending only on the strength of the field.

Effect of Magnetic Field.

Merritt and Stewart found it necessary to regulate the strength of the applied field between narrow limits, in order to obtain sharply marked effects. Their results show that photo-electric rays are magnetically deflected, in the same way as cathode rays. The amount of deflection of the photo-electric rays which is produced depends on the potential of the cathode, since the effect of increasing the potential of the cathode speeds up the rays, or makes them "harder."

These two workers also formed the opinion that there were present, in addition to the ordinary photo-electric particles, heavier and slower moving particles, probably ions. These they attributed to ionisation of the residual gas in the tube, and we have seen that this view was borne out by later experiments, while studying the effect of a gas on the photo-electric effect. This served to explain discrepancies in J. J. Thomson's work which he had attributed to experimental error.

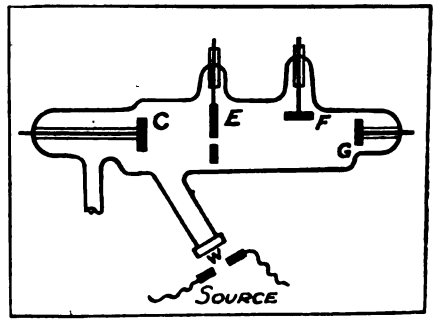

Fig. 5.
Lenard's apparatus for investigating and measuring the velocity of photo-electric particles.

Lenard went a step further than Merritt, by determining the velocity of the particles. His apparatus, shown diagrammatically in Fig. 5, consists of the aluminium cathode *C*, illuminated through the quartz window *W* by light coming from a spark between zinc terminals. The earthed

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electrode, E, had a central aperture, 5 mm. wide, through which the rays passed. The subsidiary electrodes, as in Merritt's apparatus are shown at F and G. In a similar manner to that already described, the photo-electric rays were shown to be cathode rays moving down the tube from C.

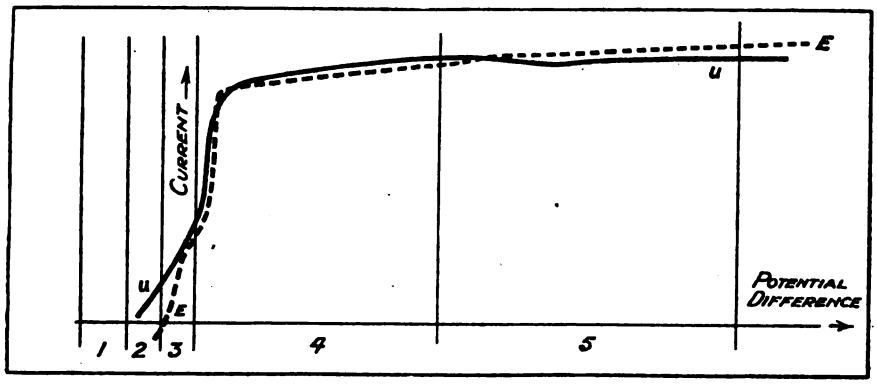

Fig. 6.
Velocity distribution curves obtained by Lenard.

Determining Velocity of Particles.

If P is the potential of the cathode C (measured in E.M.U.) v_0 is the initial velocity of the particles, and v the final velocity due to the electric field.

Then difference in kinetic energy $=\frac{1}{2}m(v^2-v_0^2)$, which we know to be equal to the product of the potential and the charge on the particle, i.e., $= Pe$.

Also, the initial velocity of the particles can be determined from the equation $P_0 e=\frac{1}{2}mv^2$, where P_0 is the *positive* potential which must be given to the cathode C, to cause the particles to return to it. The value of this potential has been found to be 2·1 volts. Re-writing the equation as $v_0=\sqrt{2P_0 e/m}$, we obtain for the value of the initial velocity v_0 of the particles 10_8 cm. per sec.

This experimental determination of the particle is incomplete, in so far as it only gives us information about the fastest moving particles. Those whose velocity is less than the maximum will return to the illuminated electrode under the influence of a potential less than +2·1 volts. Lenard himself realised this, and set about determining what is called the *velocity distribution curve.*

He determined the quantity of electricity discharged *per unit time* (per second) when the applied potential was varied. The illuminated plate was of aluminium coated with turpentine black. Two velocity distribution curves are shown in Fig. 6. The continuous line refers to the charge leaving C, obtained by applying a potential to accelerate the electrons leaving C, and the dotted curve the electric field tending to drag the particles back, gives the charge reaching E.

The curves can be divided into five stages, as shown, which are:

1. The retarding field is large, and any electrons leaving C are dragged back before they have gone very far from the plate. Both C and E are negative, due to reflected light causing a small discharge from E to U.

2. Here the retarding field is less, and electrons do manage to escape from C, but are unable to reach E. Thus E has a fractional negative v value, and C a small positive value.

3. At this stage, the retarding field is so small that some electrons manage to reach E, instead of being stranded on the glass walls of the vessel. E, therefore, becomes positive in value.

4. The field now becomes an accelerating one, of small value, and the two curves practically coincide.

5. The accelerating field is now so large that the value of the current becomes almost constant, as is shown by the curves becoming nearly horizontal.

Complications arise from the reflection of light from C to E, where a secondary electron is produced. One must ascertain the fraction of light reflected, and this depends, of course, on the surface of the electrode C and the source of light. This fraction known, the curves can be corrected. There will be a null point in this curve, and it has been calculated that for a potential difference of 1 volt, the velocity of the electrons may be taken as $5{\cdot}93\times10^7$ cm. per sec.

Space Charge.

In a previous article, we referred to the anomalies which arose through the confusion of "space charge" with other phenomena. In this work, too, numerous attempts were made to explain certain behaviours by saying that electrons were reflected from the electrodes, or from the walls of the apparatus. These things can be better explained on the basis of "space charge," i.e., the accumulation of electrons in the space between the electrodes. There is no doubt now, that electrons are reflected from metal surfaces, in much the same way as waves, as is shown by the work of Davisson and Germer. This would lead us to believe that the electron is in the nature of a wave, or at least, that it has associated with it what is termed a "phase-wave," though this need not concern us here. In order to overcome any difficulties arising from electron

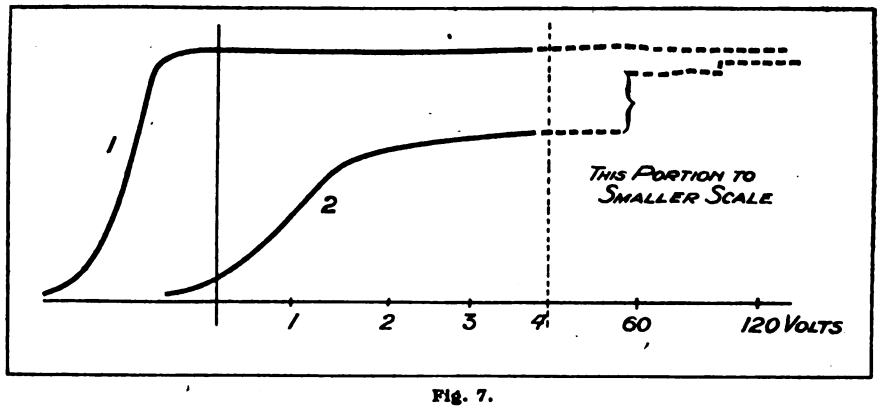

Fig. 7.
Velocity Distribution Curves.—Curve 1: With charged gauze. Curve 2: Without charged gauze.

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reflection a perforated screen and an auxiliary field was used by O. v. Baeyer. This prevents any reflected electrons from reaching the plate under test. Fig. 7 shows the effect of cutting out "reflected" electrons. Curve 1 was obtained with the electrified gauze screen, and curve 2 without the screen. It might be pointed out, in passing, that the negatively electrified gauze is not a perfect screen, there being a stray field through the apertures of the gauze.

Another Source of Error.

In 1912, Compton drew attention to yet another source of error in estimating the true value of the potential difference for a velocity distribution curve. I refer to the existence of a contact potential, since the electrons will be acted on by any potential difference due to this cause, while moving between the two plates.

There is much more interesting work both on this subject and on a number of others, which might be included under the heading of "early experiments," but it is necessary to keep this article within reasonable bounds. This seems a convenient place to pause, and I would certainly recommend my readers to study the foregoing very carefully, as an example of *method*, if nothing else.

Living Pictures.

(*Concluded from page* 251.)

"Is it being done?"

"A start has been made. Listen, Ronald! Would you always draw flowers and birds if you could see with your own eyes the fretted lattices of Cairo, the seven domes of St. Anthony of Padua and the turrets of Milan, the little flowery garden of Gethsemene, the Pagodas of the East and the gate of the Taj Mahal? . . ." I paused for breath.

"You have travelled a lot," he said.

"Only in the realms of gold," I answered, shamefacedly, "I shall be as glad to see them as you will."

"Oh, I don't know," he drawled unconcernedly, stooping to see better a little bloom of blue speedwell like a sapphire in the grass.

"They will be able to transmit whole evening programmes soon," I urged. "Perhaps a great artist will teach drawing and painting now and then, and illustrate as he speaks."

"Could he do that?" asked the boy with an air of polite interest rather than credulity. "An artist stayed here for six months once. He taught me a bit. That is why I do it."

I had one foot on the pedal. The boy looked at me full again, and for the second time I felt the strange influence of personality, the impression of a limpid and exquisite purity.

I gave a tentative push.

"You coming this way again?" he called.

"Next month," I said over my shoulder.

"Tell me some more about the living pictures," he cried, cupping his hands.

He scuttled back over the field, and I took the road, soberly.

Truly a little rascal; truly of the country, and slow to give in. But I had captured him for all his seeming indifference.

Wireless for Yachts

The latest addition to yachts fitted with wireless is Sir William Berry's motor yacht *Sona*, which is equipped with a comprehensive Marconi wireless installation, including a broadcast receiver.

For telegraphic communication over a very wide range the latest type of Marconi valve transmitter with a power of 1½ kilowatts is installed. This has been designed to transmit, in accordance with the recommendation of the Washington Conference, or interrupted continuous waves between 600 and 800 metres. In addition, an extra channel of communication is provided for transmission on continuous waves between 1800 and 2600 metres. The valve receiver for the telegraph service covers a wave length range of from 320 to 27,000 metres. This makes it possible to receive on one instrument all weather and navigation reports, news bulletins, time signals etc., in addition to the normal telegraphic traffic from local and long distance stations. In the event of failure of power, valve or battery trouble, or other emergency, a small quenched spark transmitter and a crystal detector are carried.

A four valve broadcasting receiver working from a separate aerial, and with a number of loud speakers will provide entertainment for those on the yacht. The loud speakers will be ranged where required, leaving the receiver in a central position.

The Story of Chemistry.

(*Concluded from page* 253.)

those weighing 7 are in the preponderance, and give an average value of 6·94.

Composition of Lithium Atom.

The lithium atoms contain three planetary electrons, and on their number and arrangement we believe that the chemical properties of the element depend. Thus, the two isotopes must also have three planetary electrons, because they are indistinguishable chemically.

If there are three planetary electrons, then the nucleus must have three *free* positive charges, that is, three *free* protons, to balance them and leave the atom electrically neutral. A proton is a hydrogen nucleus with a weight of 1. The weight of the electrons being negligible, the isotope of lithium weighing 6 must have six protons. With these must be associated in the nucleus three electrons, leaving three free protons to balance the three planetary electrons.

Similarly the isotope with weight 7 will have, in the nucleus, seven protons and four electrons, again leaving three free protons and three planetary electrons. Both atoms will have the same properties in virtue of the planetary electrons, but will have different weights.

Further Research Required.

Prout and his immediate followers thought of a simple packing of hydrogen atoms. This, however, will not meet the case. The mass of the hydrogen atoms is 1·008, and not unity, on the scale which fixes the weight of the oxygen atom as 16. Therefore, in the building up of the other atoms there appears to be a loss of mass.

The next lightest atom is that of helium, weighing 4 exactly. If this obtained by the uniting of four hydrogen nuclei to form the new nuclei, then there is a loss of 0·032 to be accounted for. Considerable speculation has taken place on the structure of the nucleus of atoms. One theory, supported by radio-active phenomena, is that the nuclei of the heavier atoms consist of helium nuclei. Another view directly opposes this, but further work will be necessary before a definite decision can be reached.

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A Quantitative Analysis of Television

Some Extensions of the Theory and a Reply to Criticisms

By J. H. OWEN HARRIES, A.M.I.R.E.

Some extensions of the theory given by the author in the paper which appeared under the above title in the May issue (pp. 105–112), and a reply to various criticisms of the thesis.

I WISH first to thank all those who have replied to my request for opinions on my work, and particularly Sir Ambrose Fleming for the honour of the comments of so distinguished a scientist as himself.

It is especially gratifying for me to note that Sir Ambrose makes no criticism of the correctness of my methods of analysis.* His remarks may be summed up as (*a*) that further undiscovered factors are needed to produce a complete system of quantitative measurements, and (*b*) that therefore my work is "yet premature."

In reply to (*a*), since much of the very phenomena to be eventually measured has probably not yet been invented, one cannot imagine anyone disagreeing with Sir Ambrose here. His test card method is of great interest. As it seems possible that this might become a standard measure of overall experimental results, it may be of historical interest in the future to draw attention to the fact that the Baird Co. has used large type for some considerable time for demonstration work in connection with "telereading," *i.e.*, printed messages are held up before the transmitter and legibly reproduced on the screen of the receiver.

Dr. Ives and his colleagues have used a tapering line test card (Fig. 1) and a diamond pattern (Fig. 2) for various purposes.†

But, referring to (*b*), with all due respect to my distinguished critic, I cannot for one moment admit that, because the practical work of invention in a new branch of engineering is by no means complete, quantitative work is, therefore, premature. I have no space to enlarge on this, but I submit that one has only to study the history of science to see that quantitative theory has gone hand in hand with experiment, each helping the other on from first to last, in evolving any of the great engineering achievements in the world.

Sir Ambrose Fleming's Valuable Work.

Of all the branches of engineering, that of wireless perhaps shows this best. For example, Sir Ambrose's own early quantitative work, in collaboration with Senator Marconi's inventive genius, was not premature, and led to many essential inventions, despite the fact that then (and to a great extent now) the only final criterion of success was the experimental results aurally observed at the receiver.

(Needless to say the relative importance of this classical work of Sir Ambrose's, and that of my attempt to give a quantitative basis to, and an interpretation of, television research,* has nothing to do with the argument.)

Then, surely, unless my methods of analysis are proved to be incorrect, my claim is substantiated that any experimentally found factors in the future must be complementary to, and not antagonistic to, those I have given.

I make no more detailed claims for the usefulness of my theory at the moment, but merely comfine myself to suggesting that readers should try the method in their work and, if possible, publish the results—"the proof of the pudding is in the eating."

In the meantime, if the example of its practical working given below is compared with any ordinary attempt to describe a televisor the result will be found, I think, to be illuminating.

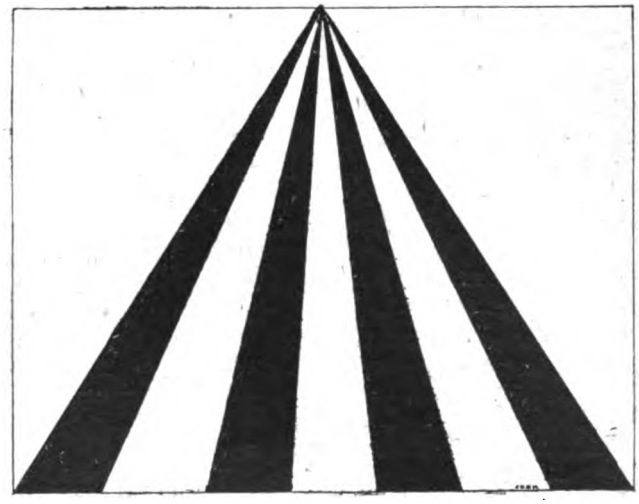

Fig. 1.

A Test Card used by the A.T.T. Co. of New York. The distance from the apex of the converging triangles at which they are resolved is a numerical over-all measure of "clearness." This card avoids errors due to the observer unconsciously guessing the words or letters on a type test.

* *In his article in our June issue Sir Ambrose Fleming said:*

"Mr. Harries deserves a compliment on his effort to bring this new art within the dominion of mathematical analysis. There are, however, some factors in it which I think have been overlooked in his attack on the problem, and to which I should like to direct attention."

† *Bell System Technical Journal*, Vol. VI. October, 1927. Pp. 582 and 649.

* See the introduction to the original paper.

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Extensions of the Theory.

As I stated at the informal discussion before the Television Society,* previous to seeing Sir Ambrose's article, I had no time when I wrote my original paper to pursue the matter further than was required for my own work then; but that the basic formula—

$$R = \frac{A}{f_{max}\, t}$$

and the analysis expresses general relationships from which many extensions may be made.

I will repeat a few of these extensions now, as from the practical viewpoint they are perhaps more interesting than the formulæ at which the first paper stopped.

It is as well to remark first that (H) in the original analysis only referred to the lengthways definition.

Where a unit of breadthways tolerance is needed we have—

$$H_b = \left(\frac{A}{A_0}\right) - 1 \quad \ldots \quad (9)$$

where

A_0 = the area of maximum definition of the system employed.

A = the area used in practice.

For comparisons to be valid A_0 must always be calculated from the standard value of β, and not found by observation, when variations in the acuity of the observers' eyes, and other effects, would cause inaccuracy.

In comparing "televisors" I suggest finding the answers to the following questions:

1. What is the value of the area of maximum definition of the system to be assessed?

2. What is the value of—

$$\frac{f_{max}}{t} = L_e \quad \ldots \quad (10)$$

That is, what is the efficiency of lengthways definition;

These units, we must note, do not measure the amount of detail we can actually see, but that which is transmitted. What we can see depends on practical considerations, *e.g.*, the tolerance ratio, etc.

3. Under what conditions does the designer intend his system to be used?

(The tolerance ratio and other points which are of interest.)

Proceedings of the Television Society, June, 1929.

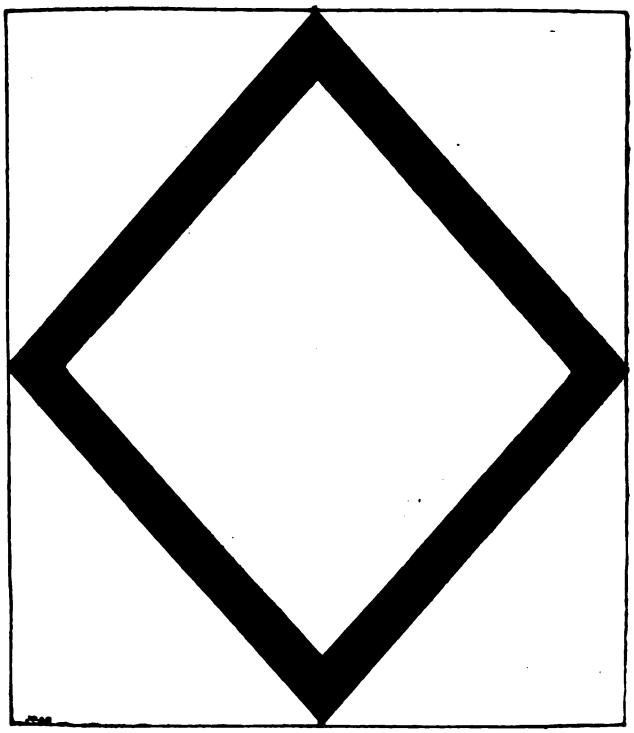

Fig. 2.

Another Test Card used by the A.T.T. Co.

Applied especially to studying fading and "ghost" images.

I will now give an imaginary report on a system such as might appear in a technical journal.

A Practical Example.

"Mr. Jones' new scanning disc is so much of an improvement that the area of maximum definition of his system is now 0·01 rad². This is double the previous best of Mr. Green's of 0·005 rad². Both are calculated with the usual standard value for β of 0·00065 to 0·0007 rad.

"Mr. Jones uses a top frequency of 40,000 cycles and a picture rate of 16 a second. The lengthways efficiency of analysis is therefore—

$$L_e = \frac{40{,}000}{0{\cdot}06} = 6{\cdot}66 \times 10^5$$

"This is an advance due to a new transmission system.

"Regarding the working conditions, Mr. Jones uses a breadthways tolerance of 4 times, which gives the working area $A = 0{\cdot}01 \times 5 = 0{\cdot}05$ rad². We then have for the working scanning ratio $R = 20 \times 10^{-6}$. Reckoning the standard scanning ratio to be $0{\cdot}57 \times 10^{-6}$ as usual, we have for the lengthways tolerance $H = 34$—rather a high value—but Mr. Jones is nevertheless to be congratulated on his work."

And so on.

A point of interest is that f_{max} is more properly defined as the cut-off frequency of the whole system. The radio band-width is probably as good a measure of it as any, however, as at the present state of the art it is the main limiting factor here.

The values, for the two examples of television systems given in the first paper, of the new units introduced at the discussion are given in the table appended.

	H_b	L_e
Mr. Geloso's system	0·73	$3{\cdot}75 \times 10^4$
Dr. Alexanderson	9·3	15×10^4

We may note that Dr. Alexanderson's lengthways working definition is very much better than Mr. Geloso's, but that the breadthways is very much less. Taking into account the results reported in the main paper, we may note that the extra efficiency in the one dimension has made up for the large tolerance in the other.

Referring to the letters contained in the June issue of "TELEVISION," perhaps I may point out to Mr. T. M. C. Lance, and others, that the standard is not necessarily the "ideal"; but merely what it is called—a standard of comparison—so one

(*Continued on page 272.*)

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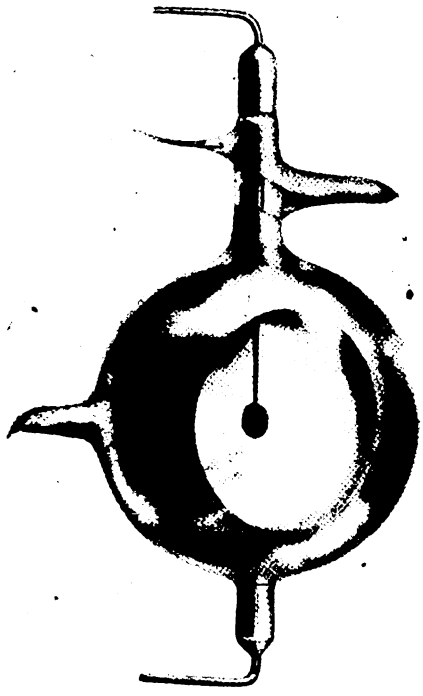

A Review of Commercial Types of Photo-Electric Cells

The performance of photo-electric cells has received the attention of at least one big Electrical Company in this country in recent years, and their Research Department has now succeeded in producing a cell which is sensibly stable in operation. This cell has now been put on the market. The following notes will, therefore, prove of considerable interest to our readers.

Choice of Photo-Electric Cells.

PHOTO-ELECTRIC cells may be classified according to (1) the size and geometrical form of the bulb and the electrodes; (2) the material used for the cathode; (3) the gas-filling.

Vacuum and Gas-filled Cells.

In a vacuum cell the current is that carried by the electrons directly liberated from the cathode by the light; in a gas-filled cell this primary current is magnified by the production of secondary electrons when the primary electrons travel through the gas.

Vacuum cells, containing no gas-filling, are preferable in everything but sensitivity. If accuracy is required, efforts should be made to use lights strong enough to give the requisite current in a vacuum cell, and to use the current to the best advantage, so that only a small current is required. But for most industrial purposes, and especially in television work, where sensitivity rather than accuracy is the first requisite, gas-filled cells are necessary. The choice of the nature and pressure of the gas requires care; but this is a problem for the manufacturer, not the user. Osram photo-cells are actually filled with argon to a pressure of about 0·15 mm.

The Material of the Cathode.

The primary current is proportional to the amount of light falling on the cathode; the constant ratio of the current to this amount of light is called the emission. The emission varies very greatly both with the material of the cathode and with the quality of the light.

The light-sensitive metal used for the cathode may be potassium, sodium, rubidium or caesium. Sensitivity curves for most of these metals will be found in the June issue of this magazine, p. 209, Fig. 1.

The cathode known as "potassium-on-copper" consists of a very thin film of potassium deposited on an underlying layer of copper by a process developed by the General Electric Company. The other cathodes consist of thick layers of the metals named, "sensitised" by a well-known process involving the use of an electric discharge through hydrogen.

The materials differ enormously both in the absolute values of their emission, and in its variation with the wavelength of the light. Further, it varies very considerably with the manner in which the material is prepared, and with its treatment after preparation.

Size and Form of the Cell.

In a vacuum cell the size and the form of the bulb and electrodes have no effect upon the current obtained with a given amount of light incident on the cathode; but, of course, if the cell is exposed to diffused light, the larger cathode will give the greater current, because it receives more light. But a cell in which the cathode is not part of the wall of the bulb is more regular in action; and this form of construction is adopted in vacuum Osram photo cells.

In gas-filled cells, on the other hand, the size and form may make considerable difference to magnification of the primary current by the gas-filling. The effect of various possible changes in size and form are too complex to be discussed here in detail. The standard gas-filled Osram photo cell has electrodes which are approximately parallel planes contained in a bulb about 5 cm. in diameter. It is believed that this is the best construction if the object is to obtain as great a current as possible, approximately proportional to the illumination, when the amount of light falling on the cell is between 0·01 and 1 lumen. The "plane" form has also important advantages in connection with the special circuit for amplifying photo-electric currents described later.

For the detection of very minute lights, such as are important to astronomers and other scientists, but

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not to most industrial users, another form of cell has advantages. This consists of a very small anode at the centre of a spherical bulb 6 cm. in diameter, the wall of which forms the cathode, apart from a window for the admission of light. A cell of this form is the "spherical" Osram photo cell, and is illustrated at the head of this review.

Voltage-Current Characteristics of the Standard Osram Cell.

The standard Osram photo cell (Fig. 1) has a cathode of potassium sensitised by the discharge in hydrogen, and is filled with argon. The cathode is a layer deposited on the silver coating on the bottom of the cell; the anode is the ring, covered with gauze, parallel to it. Potassium is the cathode most suitable for use with any light that is *roughly white*, that is to say, light from sources used for general illumination, such as the sun or incandescent electric lamps. The purpose of the argon filling is to magnify the primary photo-electric current, which consists of a stream of electrons emitted from the cathode when light falls on it; these electrons travel through the gas under the attraction of the positive potential on the anode, ionise the molecules of the gas, and set free other electrons which are added to the primary stream. The amount of this magnification depends greatly upon the voltage applied between cathode and anode; a careful consideration of this matter is, therefore, necessary.

Fig. 2 shows the voltage-current characteristics of a typical cell under different illuminations. The ordinates are the currents through the cell plotted on a logarithmic scale; the abscissæ are the voltages between cathode and anode. The meaning of the second row of horizontal numbers will appear presently. The numbers marked against each curve are the amounts of light incident on the cathode, measured in lumens, the source being a 200-volt 100-watt Osram gas-filled lamp.

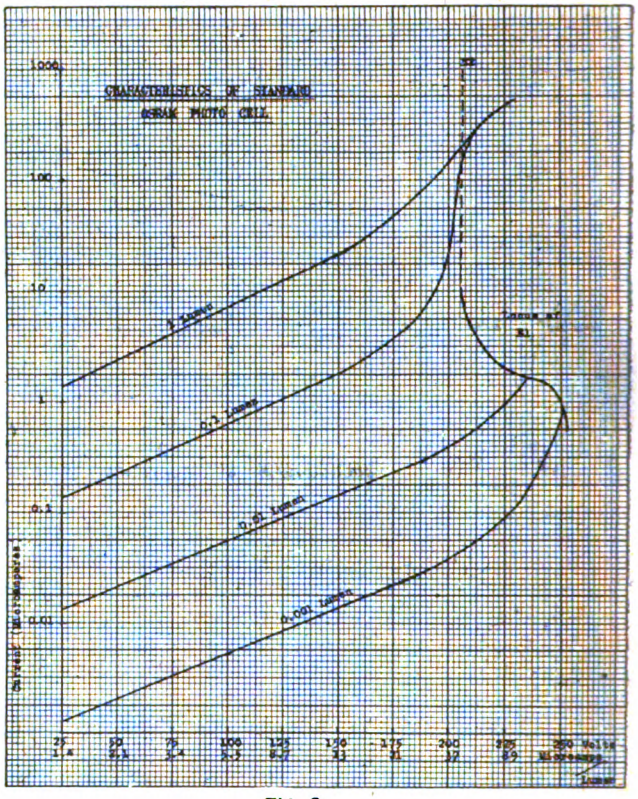

Fig. 2.
Characteristic curves of standard photo-electric cell.

If L_0 is the number of lumens emitted by the source and r its distance from the effective cathode, of which the area is S, the number of lumens incident on the cell is given by

$$L = L_0 S/4\pi r^2,$$

r is here supposed large compared with the largest dimension of the source. If there is no obstruction between source and cell the effective cathode is the actual cathode; if a screen with an aperture is interposed, which cuts off some of the light from the cathode, the effective cathode is this aperture; if a simple lens is interposed to concentrate the light on the cathode, it is the aperture of the lens.

If the illumination on the cathode is I foot-candles or metre-candles, then the lumens incident upon it are IS, where S is measured in square feet or square metres respectively.

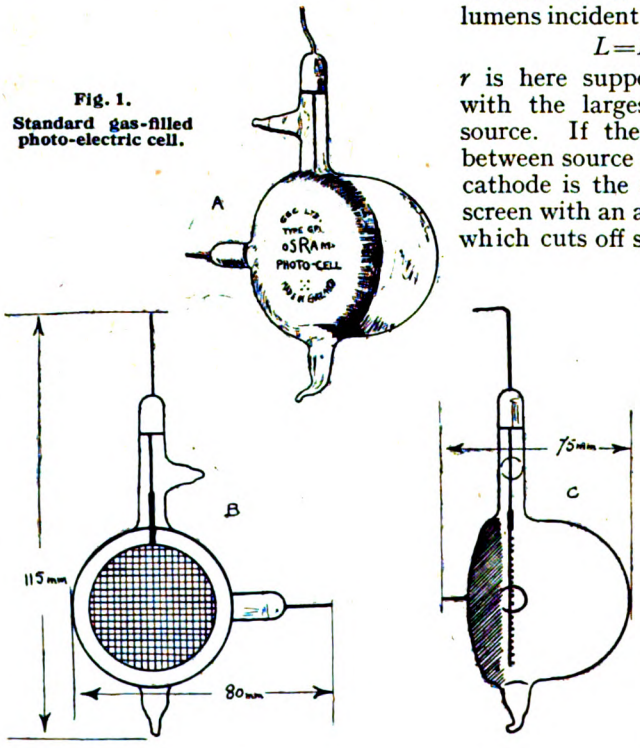

Fig. 1.
Standard gas-filled photo-electric cell.

A gas-filled lamp may be taken as emitting 12 lumens per watt of electrical energy consumed. If sources giving light of a different colour are employed a correcting factor must be applied to the lumens marked against the curves. Thus 1 lumen of daylight is equivalent in its photo-electric effect to 6 lumens from the gas-filled lamp, and 1 lumen from a vacuum incandescent lamp to 0·75 lumen from the gas-filled lamp.

Adjustment of the Voltage.

Let us now consider the effect of varying voltage at constant illumination, which we will take first to be comparatively small. The current increases with the voltage at an ever-increasing rate, until the characteristic cuts the lower part of the thick line on the right of the diagram (Fig. 2).

At this voltage (the glow potential E_1) a discharge passes through the cell, which becomes filled with a purple glow; the current rises suddenly and enormously to the value corresponding to the point on the upper part of the thick line for the same voltage; it is now independent of the light and will not stop when

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[Photo by courtesy of G.E.C.]
A type of Osram cell.

the light is turned off. If the voltage is now decreased, the current will fall along the upper part of the thick line until the vertical portion is reached at the stopping potential E_2; then the glow discharge ceases and the current falls back on to the original characteristic.

On the other hand, when the illumination is comparatively large, the characteristic merges slowly into the upper part of the thick curve. When it reaches this curve the current again becomes independent of the illumination, but there is no sudden increase of current. Whether the glow potential has been reached can be ascertained only by turning off the light and seeing whether the current stops.

If the greatest possible current is required for a given light a voltage just below the glow potential must be used. But the glow potential varies with the light and is lower the greater the light (unless it is very great). The greatest voltage that can be applied is the glow potential for the largest light that is to fall on the cell during use. The general rule for obtaining the greatest output is therefore to throw on the cell the greatest light to which it will be subjected; raise the potential till the glow discharge starts; reduce it immediately till the glow ceases; and then raise it to a value slightly (say 5 volts) below the glow potential. In order that the cell shall not be damaged by the discharge it is most important that a protecting resistance of not less than 10,000 ohms should be placed in series with it; and it is not advisable to allow the discharge to continue for longer than is necessary to observe that it has started.

If the cell is to be exposed to very strong lights (e.g., full daylight) the greatest value of the voltage that can be used is the stopping potential E_2. This can be determined by raising the potential with the cell in darkness until the glow discharge starts, and then lowering it until it stops. If the voltage is now lowered another two volts a safe value will be obtained at which *the glow will never start, however much light is thrown on the cell*, and yet a good output is obtained. The makers recommend the adoption of this voltage, unless it is important to obtain the very greatest output from very small illuminations, or unless the current has to be accurately proportional to the light at large illuminations.

Next we have to consider the variation of the current with light at constant voltage.

The necessary facts can be obtained by drawing vertical lines in Fig. 2 at the constant voltages, and plotting the corresponding ordinates against the lumens marked on each curve. If the intersections of the vertical line with the curves are equidistant, the current is proportional to the light; *it will always be so proportional if the light is sufficiently small.* We may therefore mark against each voltage the ratio of current to light for small lights; this ratio, in microamperes per lumen, is given by the lower horizontal row of figures in Fig. 2.

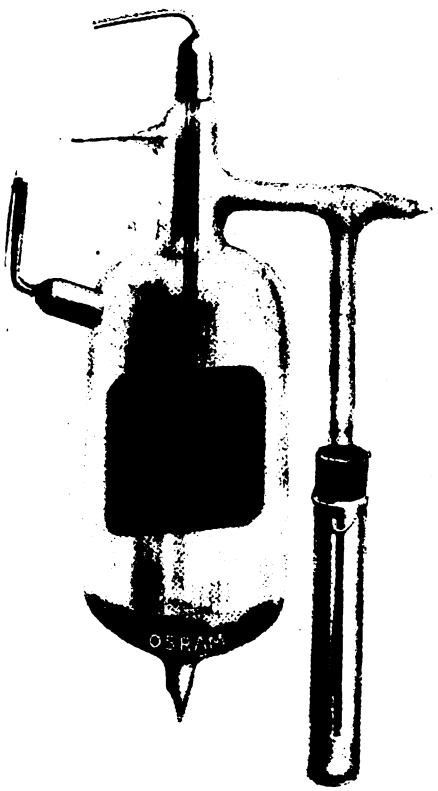
At greater illuminations the current increases more rapidly than the light, and the illumination at which deviation from proportionality begins is less the greater the voltage. If the voltage is E_2, there is a range over which the current increases enormously rapidly with the light; namely, where the vertical line passes from intersecting the curves that meet the lower part of the thick line to intersecting those that meet the upper half. If it is desired to obtain the greatest possible current from the cell from a limited amount of light, and proportionality of current to light is not important, an effort should be made to secure light sufficient to fall in this range; it should be about 0·1 lumen.

Variability of Photo-electric Cells.

There are two kinds of variability to be considered—that in the same cell according to its previous history, and that between different cells of the same type.

If the directions for adjusting the voltage of the cell are followed each time it is taken into use the cell will always start at its maximum sensitivity. The emission for the cathode is greatest just after the glow discharge has passed; after a rest of 24 hours it will drop to about one-third of this maximum value. If a comparatively large current is passed through the cell in use, obtained with a large light and a large voltage, the emission will keep at or near the maximum value; but if small lights or small voltages are used, it will fall gradually to the minimum value. If small lights are to be used, and constancy of the response over a space of an hour is important, care must be taken not to pass the glow discharge.

Again, the glow potential changes somewhat when the discharge is passed for the first time after a long interval. In adjusting the voltage according to the instructions, it is therefore well to start and stop the



[Photo by courtesy of G.E.C.]
Another type of Osram photo cell.

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discharge several times before taking the final value.

Next, it is impossible to make cells all of which have identical characteristics, and Fig. 2 must be regarded as representing only a typical characteristic. Other cells may differ from it in three ways.

1. The primary photo-electric current excited by a given light may be different. The effect of a change in this primary current is to shift the whole set of curves parallel to the vertical axis, or (for this is equivalent) to multiply by a constant factor all the numbers marked against the curves. In extreme cases this factor may lie between 0·7 and 1·3. It may even vary between these limits

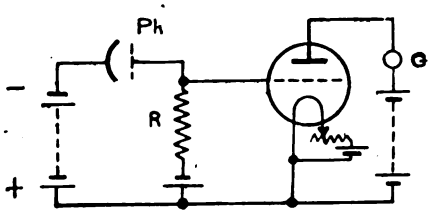


Fig. 3.
The fundamental amplifier circuit for photo cells.

over the surface of the cathode of a single cell.

2. E_1 and E_2 may be different. The effect of this change will be roughly to change the scale of the abscissæ. E_2 may lie between 210 and 150 volts. In Fig. 2 it is shown at 205 volts; if it lies elsewhere the diagram will be roughly correct if all abscissæ are changed in the ratio $E_2/205$.

3. The form of the thick line may change somewhat. The chief effect of this change is to alter the illuminations at which the current ceases to be proportional to the light, and the illumination at which, when the voltage is E_2, the very great increase occurs in the current when the light is increased. These limiting illuminations may change in a ratio of about 3 to 1.

VALVE AMPLIFICATION

The Fundamental Circuit.

Although the current through a photo-electric cell increases when the light incident on the cathode is increased, the current obtained with such light as is usually available *does not exceed a few micro-amperes*, and is often very much less. In the laboratory such small currents can easily be measured with galvanometers and electrometers, but for most industrial purposes, and particularly when the changes of light have to operate automatically, some mechanism or further electrical circuit, the currents must be amplified. The increasing use of photo-electric cells in recent years is due largely to the development of thermionic valves, which make amplification possible.

The fundamental circuit, from which all others may be regarded as derived, is shown in Fig. 3. But the exact arrangement of Fig. 3 is seldom the best; the modifications of it appropriate to particular purposes must now be considered.

Detection, Burglar Alarms, &c.

First the cell may be wanted merely to detect the presence of light and operate a relay when light falls on it. The resistance R may then be omitted. In its absence, when no light falls on the cell, the grid of the valve is insulated and takes up a potential such that there is no grid current. If a power valve is used, for instance an Osram P.625 with 150 volts on the anode, the corresponding anode current will be about 20 ma.

When light falls on the cell the current from it charges the grid negatively; this negative charge cannot escape from the grid through the valve, except in the form of "backlash" carried by the positive ions in the valve; consequently, if the photo-electric current is greater than the backlash, which is of the

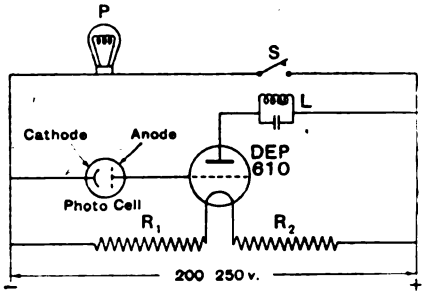
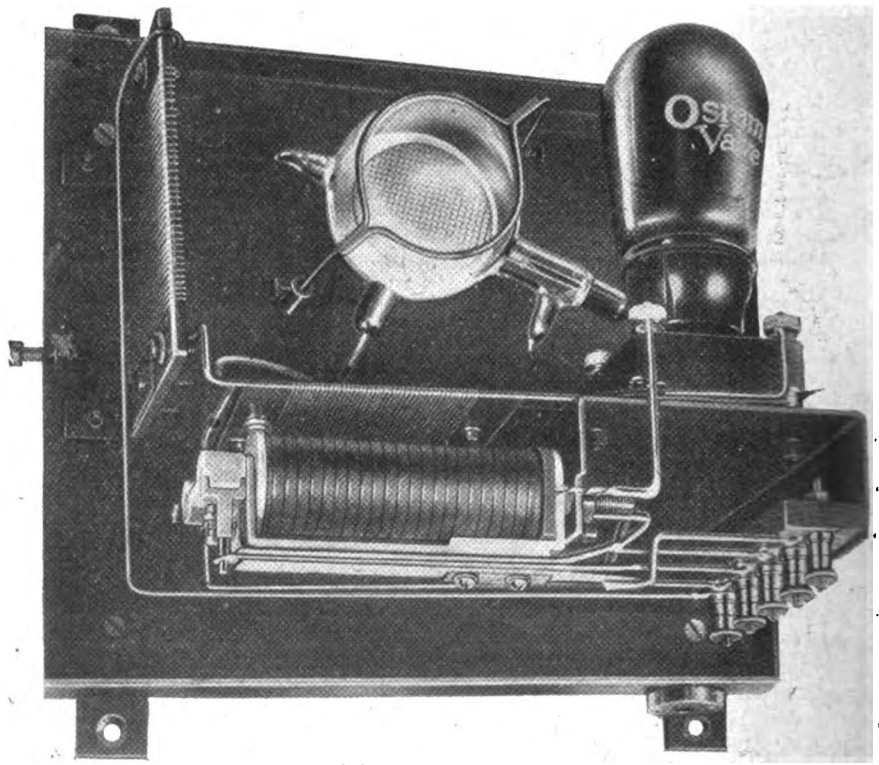


Fig. 4.
The circuit of the new Osram photo-cell amplifier, shown in Fig. 4a.

order of 10^{-8} amperes, the negative potential of the grid increases until it is equal to that applied to the cathode of the cell. If this potential is more than 30 volts, the anode current will cease entirely. Accordingly the effect of light is to stop the current in G. In this and all other arrangements, the insulation of the grid must be good, in order that it shall not pass any current comparable with the small photo-electric current. Some valves may have to be rejected on the ground of insufficient insulation.



[Photo by courtesy of G.E.C.]

Fig. 4a.
The new Osram photo-cell amplifier, a complete self-contained unit comprising one-valve amplifier, standard Osram photo-cell and 50 ma. relay. The amplifier is designed to work off the mains.

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If mains are available giving 200 volts or more, a further simplification is possible, shown in Fig. 4. The cathode voltage of the cell, the anode and filament voltages of the valve are all derived from the same circuit. The resistances R_1 and R_2 are adjusted so that the correct current flows through the filament and the correct voltage to the anode; the difference between this anode voltage and the voltage of the mains is applied to the cathode of the cell. Thus, if the mains give 200 volts, and a P.625 valve is used with 150 volts on the anode, R_1 and R_2 should be 200 and 600 ohms respectively. If the supply is A.C. a condenser of about 0·0005 mfd. should be inserted across the cell.

When no light falls on the photo-cell, a current flows in the anode circuit of the valve. As soon as light falls on the cathode of the photo-cell the grid of the valve assumes a negative charge, and the anode current of the valve is stopped.

This change of current through the operating coil of the relay closes the secondary contact S, and lights up the indicating lamp P. The change in current through the relay-operating coil is about 10 milliamps. The secondary contacts will carry about 50 milliamps. Larger currents can be dealt with by a further relay circuit in place of the lamp P.

If the photo-electric current is as great as 0·1 microampere the circuit

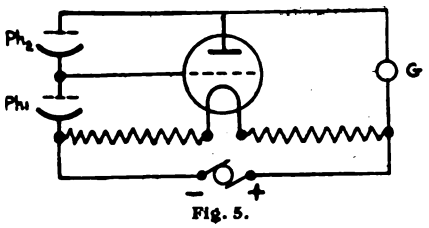

Fig. 5.
An indicator circuit using two photo cells.

will operate in a very small fraction of a second when the light is turned on; but the restoration of the anode current when the light is turned off will not be so rapid, because only the small backlash is available to restore the grid to its original potential. Speed may be increased by inserting a grid leak of several megohms, through which the negative charge can flow away; but sensitivity is thereby sacrificed. A better plan, which often has subsidiary advantages, is to employ a second photo-electric cell, as shown in Fig. 5, on which is thrown a constant illumination. The anode current will now flow if the photo-electric current in Ph_2 is greater than that in Ph_1, but will cease if it becomes less. If both cells are illuminated by the same source, the lights on them can be adjusted so that a very small

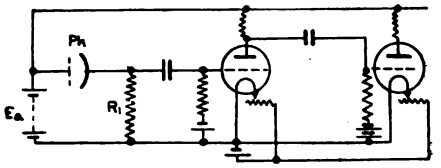

Fig. 6.
A resistance-capacity coupled amplifying circuit.

decrease in that falling on Ph_1, due to the introduction of absorbing matter before it, stops the anode current; the amount of absorbing matter required will be almost independent of variations in the light sources.

Fluctuating Lights.

In the application of photo-electric cells to such purposes as picture telegraphy, talking films, or television, variations of light occurring with frequencies up to 10,000 per second have to be translated into corresponding variations of amplified current. Here the problem is very similar to that of audio-frequency amplification in radio-reception. The coupling between the cell and the first valve need no longer be conductive as in Fig. 3, it may be effected by capacity or inductance, which transmit only the variable component of the current, and the difficulties discussed in the preceding section may be avoided. Coupling by a condenser is usually employed, and if it is employed also in the subsequent stages of amplification, the whole circuit becomes a normal arrangement of resistance-capacity coupling (Fig. 6).

The choice of the resistance R_1 is the only matter requiring special consideration. The greater R_1, the greater will be the variation of the grid potential of the first valve produced by a given photo-electric current, and the greater, therefore, the sensitivity. But a limit is set by distortion at the higher frequencies. The cell possesses a finite capacity C. If the frequency n of the photo-electric current is so high that $2\pi nCR_1$ is comparable with 1 there will be loss of amplitude and apparent time-lag in the operation of the cell. In order to combine as far as possible sensitivity and absence of distortion, C must be made as small as possible; the cell should be as close as possible to the first valve, in order that the capacity of the leads may be reduced to a minimum; but even then R_1 should not usually exceed 2 megohms.

And here a word may be added on the question, so often raised, of time-lag in photo-electric cells. There is absolutely no measurable time-lag in the primary photo-electric current. Some time-lag may possibly enter in the magnification of this primary current by ionisation by collision in a gasfilled cell, but there is no evidence that it is appreciable in well-made cells properly used at any audio-frequency. What appears to be time-lag usually arises from the presence of a capacity which the small photo-electric current takes an appreciable time to charge and discharge.

[Photo by courtesy of G.E.C.]
Still another type of Osram cell.

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How the French Police Proved Phonovision

By DEREK IRONSIDE

JACQUES MOULHAIN, Chief Inspector of the Sûreté at Marseilles, waved a hand dramatically towards the massive television receiver in the far corner of the room. His subordinate, Sergeant Duprez, turned a slightly bored but respectful countenance in the direction indicated.

"*Tiens, mon enfant,*" ejaculated the inspector enthusiastically. "At last our office is equipped with this latest scientific aid in our ceaseless conflict with crime. You've no idea how difficult it was for me to convince headquarters that Marseilles was more important than Bordeaux, and that we should be the first to be fitted with this apparatus. But I made them see my point of view. Bordeaux will have to wait a month to get their receiver."

"And what are the precise functions of this—er—apparatus?" inquired the Sergeant, regarding the receiver with a fascinated look such as an Australian aborigine might cast upon a typewriter. "I concede that television is an absorbing hobby and an interesting means of entertainment—I spent an evening last week at the Marseilles Television Theatre and saw a broadcast of the Folies Bergères from Paris—but I fail to see its possibilities as regards our own profession."

The Chief Inspector snorted impatiently. "I'll explain, Duprez." He crossed over to the receiver with swift steps. "The uses of this instrument are manifold. It is of the type known as a transmitter-receiver-recorder. With this red-knobbed switch pushed over to the left—*comme ça*—the apparatus is ready to transmit. With the switch over to the right, it becomes a receiver.

"Now, should you wish to record either something actually received from another station or events occurring in this room, you depress this blue-knobbed switch. It occurs to me, for example, that a record of some of the little interviews which take place here from time to time with our friends of the underworld might be of inestimable value when the friends in question come before the examining magistrate. But this seems to alarm you, Sergeant."

"I was merely wondering, sir, whether it would really be advisable to take such records. The possibility of a magistrate observing too closely our methods of evidence-extraction—sometimes called the 'third degree' by the vulgar populace would rather cramp my style here."

"That is certainly a point, my practical and cautious Duprez. But to continue. Our mobile televisor, in charge of a skilled mechanic of the Sûreté, is available for setting up at any point in Marseilles, and can be hidden behind an upper-storey window, in a tradesman's van or in any other place of concealment. Sitting snugly here, we shall be able to make most useful observations.

"In addition, secret televisors are being established at the quay, the railway stations and at the aerodrome, in conformity with a general plan of the Minister of the Interior, who is anxious that the arrival of persons from abroad shall be closely controlled. As a further refinement, hidden televisors are also being fitted in the cabins of passenger aeroplanes and seaplanes. The pilots have instructions to switch on their televisors when fifteen kilometres from Marseilles, whereupon a buzzer will sound here, and on our moving the red switch to the receiving position a view of the interior of the cabin will be seen on the screen. Should any of the passengers prove to be undesirables, we act according to our discretion."

"You said, sir," interjected Sergeant Duprez, "that it is possible to take a permanent record of a scene. How is this done?"

"It is done, my dear and stupid Duprez, by means of what is called a phono-visual attachment. The disintegrated light impulses are converted by the photo-electric cell of the receiver into electric impulses, which are in turn changed into sound-waves and recorded upon a sort of gramophone disc. You don't understand this, of course, but all you have to do is to depress this blue switch and the machine will do the rest. If . . . ."

The Chief Inspector stopped short. The buzzer inside the receiver had begun to sound.

"Somebody is calling us, you see, Duprez," explained the inspector. "Now, I move the red switch over to the right. The screen immediately becomes animated. We are looking at the face—rather too life-like and large to be actually pleasant—of our mutual friend, Inspector Levois, of the Moroccan section of the Sûreté at Casablanca. You will observe that he has not yet had his weekly shave. In a moment he will commence to speak."

Surely enough, at that moment the loud-speaker concealed inside the cabinet began to function: "Sûreté, Casablanca, calling Sûreté, Marseilles. Please give the 'Understood' signal."

The Inspector touched another switch on the cabinet.

"Your 'Understood' signal received, Marseilles. This matter is extremely urgent. Pierre Duvalier, serving seven years penal detention at Bou Haima Penitentiary, has escaped and is believed to be heading for Algiers. Can you send a man to Algiers to intercept him? I am short-handed here—half my men have dysentery."

"I know Pierre Duvalier, Inspector," ejaculated Duprez excitedly. "I have an old grudge to settle with him. Let me go to Algiers."

"*Volontiers, mon ami,*" agreed the inspector. He threw the switch over to 'transmission.' "Hallo, Levois! Moulhain, of Marseilles, speaking. Am sending Sergeant Duprez, who knows Duvalier, by

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the first seaplane bound for Algiers."

"So you know Duvalier," said the inspector curiously when he had switched off. "And your acquaintanceship was not pleasant, since you owe him a grudge."

Recognition was sudden and mutual. Even as Duprez's hand flashed to his revolver pocket the Curé leapt upon him.

"Duvalier nearly got me discharged from the Sûreté, inspector. He was one of the cleverest mechanic-crooks in Montmartre when I was stationed in Paris some years ago. I knew him very well and had warned him that one day I should have to arrest him. He was, incidentally, a master of disguise, with curiously plastic features that enabled him to adopt a fresh face almost at will. Nevertheless, I was sure that I could always get him when I wanted him. He had a peculiar habit of twitching his shoulder when excited or spoken to suddenly.

"One day, however, I was ordered to arrest him on a charge of robbery under arms, and he fooled me completely. I actually passed him in the Rue Lamarck as he was tottering along in the guise of an enfeebled old man. This was bad enough, but worse was to follow. He was accidentally arrested as a suspect by an officer in another *arrondissement*, and his true identity revealed. Out of sheer malice he broadcast the fact that I had brushed past him earlier in the day in Montmartre without recognising him. My inspector was furious, and only the merest chance saved my career from a drastic termination. But next time, inspector, I shall not miss him. He can come disguised as an Arab, a Levantine, a Maltese pedlar or an old Indian hag, but I'll get him and send him back to the hell from which he has escaped."

"You are sure you would know him again?" asked the inspector suavely. "Men alter considerably at Bou Haima, I have heard. Some have been known to prefer Devil's Island."

"I shall know him," affirmed Duprez savagely. "I'll leave by the noon seaplane for Algiers, inspector."

* * *

Nevertheless, a month later, a disappointed and disgruntled Sergeant Duprez sat in the cabin of a big seaplane at Algiers, waiting for it to commence its flight back to Marseilles. He was, apparently, to be the only passenger. He was not looking forward to his pending interview with the inspector at Marseilles, since his quest for Pierre Duvalier had been entirely futile. No trace of the man had been discovered since he had escaped from Bou Haima Penitentiary. Duprez had decided that the man must have died somewhere in the desert, but had his doubts whether this explanation would altogether satisfy his chief.

The engines of the seaplane were already roaring when the cabin door opened and another passenger was admitted. From force of habit, Duprez shot a swift glance at the newcomer—not without hope that by mere chance it might prove to be the fugitive. But the most casual glance was sufficient to set any possible doubt at rest. The new passenger was a rubicund, cheery curé, doubtless proceeding on holiday from some comfortable Colonial mission. The two men exchanged greetings, but for the major part of the journey, whilst the seaplane flew over the sparkling blue waters of the Mediterranean, they scarcely spoke again. The curé was busy writing letters, whilst Duprez, too moody in any case to engage in conversation, glowered at the sea below him. Presently, however, the curé laid aside his writing and became sociable.

"It will be pleasant, m'sieur," he remarked, "to get back to France again. Five years in Morocco at a stretch are enough for me."

Duprez laughed. "You look as though Morocco has agreed with you, monsieur le curé."

The reverend gentleman flourished his hands deprecatingly. "Physically, yes, but spiritually, no. My heart has remained in France. We are so much out of things in Morocco. Everything is so primitive. There is not a single television theatre in the whole country, you know. And I have always been interested in television. Five years ago, in Paris, I used to experiment with a rather primitive set, modelled on Baird's earlier patents, and pick up the transmissions sent out after the usual broadcasting hours. But since those days, I understand, television has become a world-wide industry."

"That is true," agreed Duprez, "we use it even in my business."

"How interesting. It would perhaps be impolite to ask what that business is and how you apply television to it."

"Well—er—I'm afraid I'm scarcely at liberty to disclose details, monsieur le curé. You see, my firm is a limited company, so that I have a duty towards my shareholders."

"Oh, exactly. Pray excuse my

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rudeness in pressing you. Hallo, we're fairly close to Marseilles now—the coastline is becoming quite clear."

Duprez noticed that the curé's voice was curiously excited. There was certainly no doubt that he was really eager to get back to France. Duprez stared at him dully, then, despite himself, the blood surged to his temples.

The curé's shoulder was twitching spasmodically. Suddenly conscious that Duprez was staring at him, the curé turned swiftly.

Recognition was sudden and mutual. Even as Duprez's hand flashed to his revolver pocket, the curé, his pleasant expression changed to one charged with ferocity and hatred, leapt upon him.

At the same instant, ten kilometres away, Inspector Moulhain, of the Marseilles Sûreté, was staring in horror at the television-screen, to which he had been called by the buzzer a few minutes earlier.

* * *

The court was crowded. Everybody was excited and perspiring, from the presiding judge downwards. Already the case had attracted enormous attention. The disappearance of a member of the Sûreté from a seaplane en route from Algiers to Marseilles was unusual enough, but for his fellow-passenger—a curé of the Church—to be arrested on arrival on the charge of murdering him added a further sensation to the extraordinary affair.

There was a general feeling, however, that this time the Sûreté had overreached themselves. The seaplane pilot had seen nothing of the alleged affray, whilst the curé had already declared on oath that Sergeant Duprez had gone suddenly mad, and despite his efforts to restrain him had flung himself out of the cabin door into the sea. There were no evidences of an affray within the cabin, and everybody agreed that the Sûreté would have a very hard task in proving their charges.

The Public Prosecutor opened the case well, but obviously made the fullest use of his imagination. His description of the curé, who sat genially in the dock between two gendarmes, as "this desperate miscreant," created laughter in court by its obvious absurdity. Anybody could see that this curé was a jolly young fellow. The case was not going to last long. They would all be able to leave very soon and have an apéritif in the Café de la République, which happened to be so conveniently near the court.

"I propose to call only one witness," concluded the Public Prosecutor. "His evidence, I think, will be decisive. We are, of course, all desirous of concluding the case as quickly as possible."

Inspector Moulhain was called.

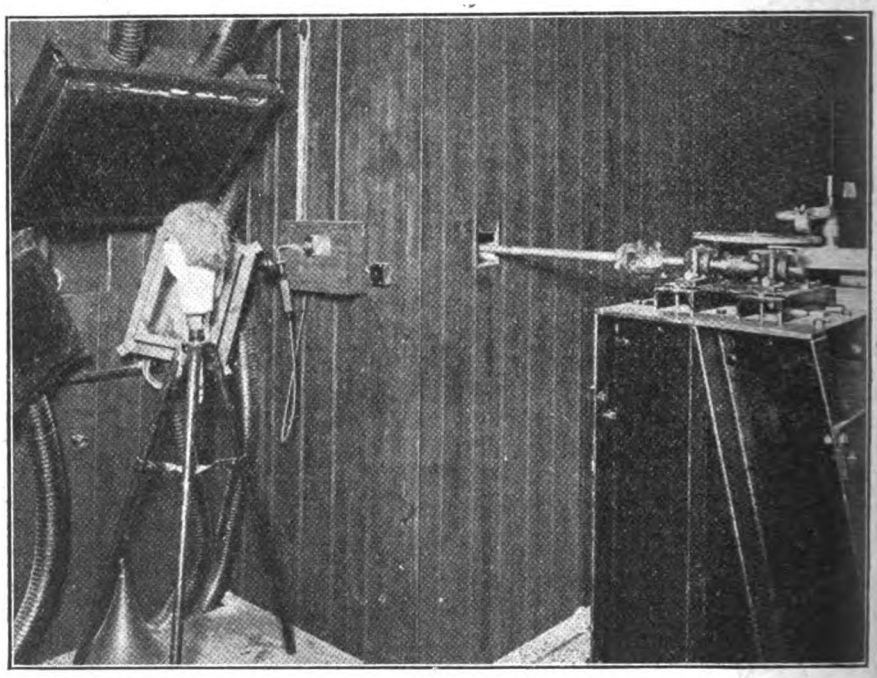
"On June 5th last," he affirmed, "I received a wireless message from Sergeant Duprez that he was leaving Algiers by the 10 a.m. seaplane for Marseilles. He had been searching North Africa for an escaped convict named Pierre Duvalier. At 5 p.m. a buzzer in my office at Marseilles announced that the seaplane was about fifteen kilometres distant.

"It is not a matter of common knowledge that in the interests of the State, all aeroplanes arriving at Marseilles are fitted with televisors which are put into operation at a certain distance from the port, so that the Sûreté may secretly examine the passengers. At 5 o'clock, therefore, I was accordingly watching the two passengers in Seaplane No. F-BMXY.

"One of the passengers I recognised as my own Sergeant Duprez, while the other, with whom he was chatting in a friendly fashion, was this gentleman now in the dock. I had scarcely been watching them for more than a minute, however, when an argument seemed to arise and the two men grappled in a desperate and violent conflict. By sheer bodily strength, the curé overpowered Duprez and, dragging him to the door of the cabin, hurled him into space. It was all the work of seconds. I accuse this curé of the foul murder of my colleague."

The curé's counsel rose and appealed to the presiding judge. "I protest against such evidence being allowed. What proof has the inspector that he saw such an occurrence on the screen of his television receiver?"

Inspector Moulhain faced the court stiffly. "I have the proof here. Our television apparatus can be adjusted to take a permanent record of anything it receives. The electrical impulses constituting the pictures received are converted into sound-waves and recorded upon a sort of gramophone-disc, this process being well known to experts as phono-visual reception. To reproduce the picture, a gramophone pick-up is used in conjunction with a television-receiver. The necessary apparatus is actually here in the



The noctovision transmitter (left) and the phonovision recording mechanism (right) in the Baird laboratories.

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body of the court, and I have here in my hand the sound-record of the scene which occurred in the cabin of Seaplane No. F-BMXY at 5 p.m. on July 5th. May I request that the court be darkened?"

Throughout the court the ushers extinguished the lights, and in a minute, save for a faint glow upon the judge's bench and in the dock, where the gendarmes guarded the accused man, the place was in darkness. A moving picture flashed into animation on the radiant screen of the inspector's apparatus.

As though spellbound, judge, counsel, the accused and the mass of spectators gazed at that living screen. There was almost complete silence save for the faint scratching of the twirling disc.

Upon the screen there had become visible the luxurious interior of a seaplane cabin, within which two men, their forms outlined against the glare of the windows, sat talking. One of the men, wearing a broad ecclesiastical hat, was obviously the accused man, whilst those who had known Sergeant Duprez had no difficulty in identifying him as the burly companion of the curé.

Suddenly the curé was seen pointing at some object outside the cabin, probably a landmark, and apparently addressing his companion rapidly and excitedly. Instead of gazing in the direction indicated, however, Duprez riveted his eyes on the curé himself, as if something about him had arrested his attention. The next moment the curé had turned, his eyes blazing with suspicion, and in a moment the two men were locked in a hideous embrace, rolling over and over on the floor of the cabin as each attempted to gain the mastery.

Within the court a profound stillness reigned as all gazed at the reproduction of that sinister tragedy that had occurred above the Mediterranean many weeks earlier. A sort of paralysis seemed to grip the silent watchers, but the spell was rudely broken by a scream from the dock that echoed uncannily in the darkness.

"*Mon Dieu*, switch it off. I'll confess everything." The curé's voice rang out dramatically through the darkened hall. There was the sound of a scuffle as the gendarmes pushed the accused man down once more into his seat.

On the screen the curé had now gained the mastery of his surprised opponent and was furiously dragging him towards the door of the cabin. Duprez seemed to resist grimly, but presently he vanished from sight. The curé, panting with his exertions, staggered into a seat.

"Note how intently he is staring at that shoulder. He has been searching North Africa for a month past to find a man with that particular habit. Ah, now the curé realises that he had been recognised. He is leaping upon Duprez before the Sergeant can draw his revolver.

The prisoner had fallen forward. The gendarmes and a little fussy man in black—apparently a doctor—were feverishly trying to revive him. Then the little man in black rose slowly, and addressed the presiding judge: "*Monsieur le Juge*, it is futile to proceed. Pierre Duvalier is beyond the reach of human justice."

The excitable French audience broke into a storm of execration. Pandemonium reigned for a full five minutes, and riff-raff from the docks demanded that the curé should be lynched out of hand. But presently the ushers and police restored order, and quiet ruled once more.

"And now," came the inexorable voice of the inspector, "I propose to show a slow-motion picture of the first stages of the fight between the two men. We shall be able to analyse the causes of the dispute. Ah, you see. They are talking, as you can observe, in quite a friendly fashion. The curé is pointing out of the window, apparently at some landmark which indicates that the seaplane is very close to Marseilles. The idea of Marseilles seems to excite and agitate him. He has a peculiar habit, apparently, when excited, of twitching his shoulder. You can all observe this peculiar habit. Sergeant Duprez also observes this action. It fascinates him—as well it might.

I think we have seen enough, so I will stop the apparatus. But who is this man with the twitching shoulder? It is not a curé on leave from Morocco. It is an apache of Montmartre, Pierre Duvalier, the man with the plastic features, the man who escaped from Bou Haima Penitentiary. I accuse Pierre Duvalier, now in the dock, of the murder of Sergeant Duprez."

The lights in the court room went up in a sudden blaze of brilliance, and all eyes were turned towards the dock, around which there was a distinct stir. The prisoner had fallen forward. The gendarmes and a little fussy man in black—apparently a doctor—were feverishly trying to revive him. Everybody stared in futile astonishment. Then the little man in black rose slowly, shrugged his shoulders despondently, and addressed the presiding judge:

"*Monsieur le Juge*, it is futile to proceed. Pierre Duvalier is beyond the reach of human justice."

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The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. each.

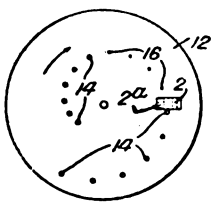

FIG. 1.

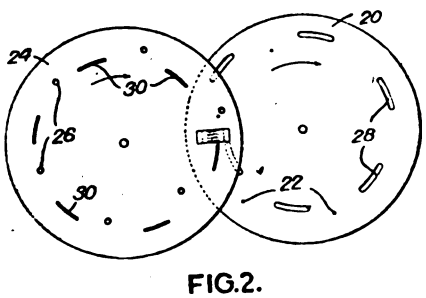

FIG. 2.

Patent No. 303771, granted to J. L. Baird and Television, Ltd.—A "graded-zone" system of exploring and utilising the known characteristic of the human eye (which sees extended scenes in greater detail at the centre) is described in this Patent specification. Fig. 1 shows an exploring disc (12) having large holes (14) with comparatively large radial spacing at one (or both) ends of the spiral, the remaining holes being small with small radial spacing. The picture area can be shifted so that the close spaced exploring lines (2a) occur at any part desired of the picture. Another arrangement is shown in Fig. 2, where the whole picture is explored in broad lines by holes (26) in one disc (24), and a certain zone of the picture is additionally explored in fine lines by holes (22) in the disc (20). The slots (28) (30) are provided to prevent interference. The distance between the centres of the discs may be varied so as to alter the location of the finely divided explored region in relation to the rest of the picture. Synthesising, or building up of the received picture, can be effected by the same means.

Patent No. 308277 (Convention date (U.S.A.) March 20th, 1928), British Thomson-Houston Co., Ltd.—The layout of a two-colour television system is indicated in Figs. 3 and 4. Interlacing lines of the picture (5) are explored by the two sets of spirally arranged holes (6) and (7) in the rotating disc (4), a source of light (1), and the disc (3) consisting of two coloured sectors (9) and (10). This disc (3) is geared to the disc (4), and has the effect of providing the holes (6) with light of one colour, and the holes (7) with light of another colour. Light reflected from the picture (5) is converted into electrical impulses by photo-electric cells (13). At the receiver, shown in Fig. 4, the exploring disc is identical with that of the transmitter, the two sets of holes being illuminated by two different coloured lamps (16) and (17), the current impulses from the

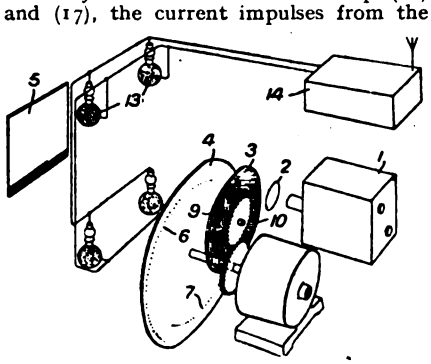

FIG. 3.

receiver being directed to the appropriate lamp through a commutator (20) mounted on the same shaft as the disc (18).

Patent No. 309224, granted to The General Electric Co., Ltd., and N. R. Campbell.—This Patent is an addition to No. 306996 (described in June issue of TELEVISION, page 214). Constancy of the hydrogen filling may be secured by providing a palladium tube in the cell. The support for the sensitive film is of a metal other than silver or platinum, and is pre-

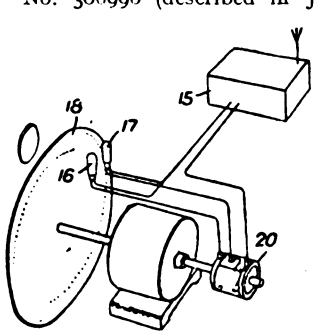

FIG. 4.

FIG. 5.

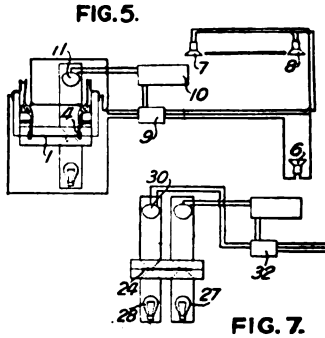

FIG. 6.

FIG. 7.

ferably copper or zinc. A preliminary layer of silver, formed on the bottom of the cell, is washed, dried, and heated to 100° C. for 15 minutes. The cell is then supported with the silvered coating vertical, and is filled with a coppering solution. A current of about 2 milliamps. per sq. cm. is passed through the solution for about 15 minutes, with a copper wire as anode and the silvered coating as cathode. The copper surface is then a matt chocolate brown colour. The cell is now washed, dried, and baked for a few minutes at 300° C. so as to oxydise the surface of the copper. The film of potassium is formed as described in Patent No. 306996, and hydrogen is then admitted.

The coppering solution is formed by preparing freshly-precipitated copper carbonate by adding a solution of 400 grams of crystallised copper sulphate in 2 litres of water to a solution of 100 grams of anhydrous potassium carbonate in 1 litre of water. The mixed solution is allowed to stand for one hour, and the precipitate is filtered off and washed. The precipitated copper carbonate is gradually added in excess to 60 grams of acid potassium tartrate dissolved in 1 litre of boiling water. The solution is filtered and allowed to stand for several days until the deposition of a blue precipitate ceases or becomes very slow.

Patent No. 309208, granted to S. K. Wilson and De Forest Phono-Films, Ltd., whereby arrangements are described for localising the sound effects in the auditorium in accordance with the topic treated in the film; for example, the sound appears to issue from the roof in the case of a film depicting aeroplanes. In Fig. 5

(Continued on page 272.)

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THE BEST LETTERS OF THE MONTH

The Editor does not hold himself responsible for the opinions of his correspondents. Correspondence should be addressed to the Editor, TELEVISION, *26, Charing Cross Road, W.C. 2, and must be accompanied by the writer's name and address.*

MECHANICAL FORCE OF LIGHT.

THE GREENS,
CARNWATH, LANARKSHIRE.
May 21st, 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

I have followed with great interest the ideas put forward by Mr. E. P. Adcock and others in the correspondence columns of your journal TELEVISION.

While offering no comment as to the utility of these schemes, I would like to draw the attention of your readers to a phenomenon which, I think, might be utilised to advantage for television purposes.

This phenomenon—namely, "The mechanical force exerted by light on being reflected"—is quite well known, and is clearly demonstrated by the small daylight machines often exhibited in opticians' windows. I put forward no suggestion at the moment as to how this force could be utilised, but I will be very interested indeed in any opinion on this subject put forward by those gentlemen (and of course ladies) who are interested in the advancement of this great new science.

Trusting this matter is of interest.

I am, Sir,
Yours faithfully,
ROBERT CADZOU.

LAG OF SELENIUM.

HYLTON VILLA,
WESTFIELD, REDCAR,
YORKSHIRE.
June 14th, 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

The "Lag" in a selenium cell, which formed the subject of Mr. C. M. Adcock's letter in your June number of TELEVISION, has been investigated during the past two years or so.

It was found that provided the selenium layer was thin enough to be penetrated by the incident light, i.e., provided the thickness did not exceed ·01 cm., and that the cell was dry, the lag was negligible.

The explanation given was, I believe, that the light liberated elections which at once recombined when the light was removed. If, however, a thick layer of selenium was used this state of affairs was only true for the thickness of the selenium penetrated by the light, the remainder suffering a secondary ionisation by the photo electrons. It is this "ionisation at a distance" which gives rise to the well known lag.

The cure for lag is obvious, if this is correct, and experiments seem to confirm this statement.

The true *cause* of change of conductivity of selenium is not yet fully understood, and I would point out that from the Quanta view point the electrons liberated and energy of incident light do not fully agree.

I am, Sir,
Yours faithfully,
R. NEVILLE GRAY.

ELECTRO-MAGNETIC WAVES

SYDENHAM, S.E.26.
1st, June 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

My letter to you, Sir, in your May number of TELEVISION had its origin in a sentence in Sir Ambrose Fleming's article in the April number.

It was not intended to provoke an elementary lecture on Physics from your correspondent in your June number, a lecture that might have been of service to me sixty years ago, but does not directly deal with the question, while it shows evidence that my letter has not been very carefully read, nor does your correspondent fully realise the position Dr. Einstein takes up now.

I had no intention when I wrote you of opening a discussion but of stating a series of opinions arising from Sir Ambrose's question on page 56 in your April number. May I be permitted to leave the matter there? While thanking you for your courtesy in affording me so much of your valuable space.

I am, Sir,
Yours faithfully,
A. HAYWOOD.
Lt. Col. (retd.)

RIANT MONT,
LA ROSIAZ,
LAUSANNE.
April 29th, 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

Mr. Wolfson's letter in your April issue was considerably interesting, and I have taken a few pains and time to see what his idea really is, but at the present moment, unfortunately, I am at loss for a correct interpretation. I can only trace, if he will excuse my saying so, a contradiction of ideas. Moreover, I can find nothing to support Mr. C. M. Adcock's idea.

As far as I can make out λ depends on the atmospheric conditions. Under two separate distinct conditions it is in my opinion possible to have too light waves of the same frequency but different wavelength. It is therefore evident that the speed of light cannot be an universal constant, as otherwise the action of the prism in separating light would be inexplicable.

Light is a subject that interests me, and I should be much obliged if Mr. Wolfson would kindly give me the titles of the books from which he obtained his

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information, as it would be beneficial to examine this question more deeply.

I feel that I must, however, thank Mr. Wolfson for his somewhat unnecessarily severe criticism, as it is leading to a deeper investigation, and I fancy that he really has a good idea if only it can be isolated.

If he would allow me to refer to his formula $Q=it$, which is perfectly correct, I would point out a slight misinterpretation. Quantity of electricity is effectively measured in amperes, as from the formula it is readily visible that 1 ampre(i) = 1 coulomb per sec. : $\left(\frac{Q}{t}\right)$ and one coulomb is not equal to the ampere per second as he would have me assume.

I would advise him to be rather more careful when applying a differential law such as Kirckhoff's, for, although the integral of the law can be verified experimentally, it does not hold that the differential law is exact, as the integrating constant is always to be remembered.

Finally, can any reader recommend me a reliable text-book where the laws of electro-magnetic radiations, and in particular those of light, are expressed as a function of all dependent variables, such as pressure, temperature, medium, etc. ? It is important to know as well exactly on what the colour of light depends, or rather what are the factors to which our sense of colour reacts, and what is the minimum variation we can appreciate.

From this it will be a simple matter to corroborate any of Mr. Wolfson's, Mr. C. M. Adcock's, or my own statements. In fact I should be much obliged for any really reliable information on the subject, for I feel that in the future television will depend to a much more important extent on an exact and precise knowledge of the nature of light, including its laws ; this perhaps explains in a measure why television has not progressed as rapidly as might have been anticipated.

I am, Sir,

Yours faithfully,

E. P. ADCOCK.

Invention and Development.

(*Continued from page 270.*)

the record film (1) is notched or cut away along the sides so as to control spring contacts (4), which, in turn, actuate a relay (9), thus causing the sound reproduced by a photo-electric cell (11) and amplifier (10) to be localised by the loud-speakers (7) and (8), or alternatively by the loud-speaker (6) as desired. The film may have perforations instead of edge notches and move between clip contacts. Volume control as well as locality may be controlled by the same means.

In a modification the selection or control may be effected by markings (26), Fig. 6, on the film record, and these markings may conveniently be on the opposite edge of the film from the sound record. Light from a source (28) in Fig. 7 is projected through such markings on to a cell (30), which controls a relay (32) acting in the same manner as in Fig. 5. The two lamps (27) and (28) may be replaced by a single lamp and two refracting prisms, which direct the light through slits on to the sound record and on to the selecting markings respectively. Alternatively, the selecting means may operate in such a way that it brings into operation another sound record, and it may also control resistances to vary the volume or control different emission orifices from one reproducer.

A Quantitative Analysis of Television.

(*Concluded from page 260.*)

need not be discouraged by calculations with it.

Mr. W. H. Hebdidge seems to have missed a somewhat essential difference between the area of maximum definition and the working angular area. This also applies to Mr. S. Goldstein's first point. I must refer these gentlemen to the definitions already given, and in particular to the paragraph in the paper headed " Resolving Power of the Eyes," as space is too limited here to give a more detailed explanation.

Taking Mr. Goldstein's second point, the data for " pictures " also applies to the use of a three dimensional object ; for in neither case, obviously, do we transmit the object itself, but only a two-dimensional (or flat) optical image.

I do not quite follow Mr. Goldstein's last point. The optical image at the transmitter is imagined to be of infinite detail. What we wish to measure is the result of transmitting this to the receiver. Therefore the " picture clearness " refers to the received " picture " or optical image.

Errata.

Two clerical errors unfortunately crept into the original paper. These were : " 10 inches " should read "about 5 inches " beneath Fig. 2, and the second part of the caption should be deleted. Also the bracketed part of the formula in the footnote on page 110 should read

$$\left(\frac{R}{R_o}\right) \text{ and not } \left(\frac{R_o}{R}\right)$$

and this expression should be numbered (5·1).

Television Society.

Having concluded a most successful session, the Society settles down to vacation. During the months of June and July outings have been arranged, to visit the G.E.C. laboratories at Wembley and the studios of British Talking Pictures, both meetings being filled to capacity. Already a complete list is arranged for the Autumn Lectures, due announcement of which will be made in our next issue.

Change of Address.

In order to be more centrally placed the address of Headquarters of the Society has been changed to 4, Duke Street, Adelphi, W.C. 2.

Special American Broadcasts for Europe.

For the purpose of providing Europeans with an American radio programme at a convenient hour, W.G.Y.'s short wave station W2XAF of Schenectady has inaugurated a series of afternoon broadcasts on two different frequencies, daily except Saturday and Wednesday. These programmes also afford engineers of the British Broadcasting Company an opportunity to carry on experiments in reception and rebroadcasting of trans-Atlantic programmes.

The afternoon schedule of W2XAF, effective at once, follows : Sunday, 2.30 to 5.30 p.m., 15,340 kilocycles ; Monday, 2.0 to 4.0 p.m., 13,660 kilocycles ; Tuesday, 2.0 to 3.0 p.m., 15,340 kilocycles ; Thursday, 2.0 to 4.0 p.m., 13,660 kilocycles ; Friday 2.0 to 3.0 p.m., 15,340 kilocycles. All time references are eastern daylight-saving time. (Five hours behind British Summer Time.)

EXPERIMENTAL work. Inventors' models. Scanning discs any size to drawings. JOHN SALTER, Scientific Instrument maker. Established 1896. Featherstone Buildings, High Holborn, W.C. 1.

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AUG 5 - 1929

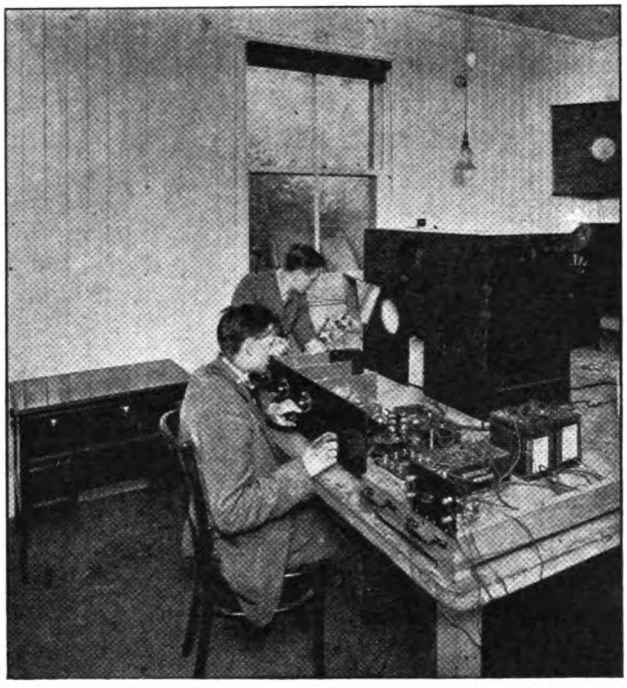
B.B.C. Hold Up Baird Television Transmissions

6D MONTHLY

Television

The Official Organ of the Television Society

VOL. 2 AUG. 1929 No. 18



WHERE GERMAN BROADCASTS OF BAIRD TELEVISION ARE RECEIVED DAILY.

An interior view of the Baird Laboratories situated in North London.

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THE WORLDS FIRST TELEVISION JOURNAL

THE TELEVISION SOCIETY

The Television Society was founded on September 7th, 1927.

The Society makes its appeal to those who desire to share in the responsibility of furthering this new branch of applied science.

THE OBJECTS OF THE SOCIETY

may be summarised as follows:

(*a*) The Study of Television and its application in applied science and industry.

(*b*) To afford a common meeting ground for professional and other workers interested in current research relating to Television and allied subjects and to afford facilities for the publication of reports and matters of interest to Members.

(*c*) To encourage the formation of *Local Centres* of the Society in the Provinces, so that by social intercourse and discussion among members these aims may be more fully realised.

The present register indicates a world-wide membership.

ORGANISATION.

The Society consists of one Honorary Fellow, Fellows and Associates, and the management is vested in a Council of Fellows, including the President, three Vice-Presidents, and Ordinary Fellows.

FELLOWS.—Ordinary Fellows must be elected by the Council. Candidates for the Fellowship must be proposed by two Ordinary Fellows, the first proposer certifying his personal knowledge of the candidate.

ASSOCIATES.—Any person over 21 interested in Television may be eligible for the Associateship without technical qualifications, but must give some evidence of interest in the subject as shall satisfy the Committee.

STUDENT MEMBERS.—The Council have arranged for the entrance of persons under the age of 21 as Student Members.

SUBSCRIPTIONS.—The annual subscription for Ordinary Fellows is 20s., with an entrance fee of 10s. 6d.; and for Associates 10s., with an entrance fee of 5s.
The annual subscription for Student Members is 5s., entrance fee 2s. 6d.

LIFE MEMBERS.—Life Membership may be secured at a fee of £10 10s.

MEETINGS.—The ordinary meetings of the Society are held in London at the Engineers' Club, Coventry Street, W.1, at 8 p.m., on the first Tuesday of the month (October to May inclusive). Notices of meetings are posted to all members about seven days before the meeting.

Full-size reproduction of the new Television Society Badge, which is available to accredited Members, and may be obtained from the Head Office, price 1s.

The official organ of the Society is "Television," published monthly by the Television Press, Ltd., 26, Charing Cross Road, W.C.2.

A memorandum for the guidance of members wishing to form a Local Centre of the Society may be obtained (gratis) on application to the Joint Hon. Secretaries, 4, Duke Street, Adelphi, W.C. 2.

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Television

THE WORLD'S FIRST TELEVISION JOURNAL

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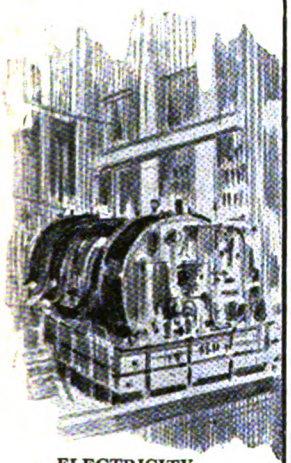

ELECTRICITY

MECHANICS

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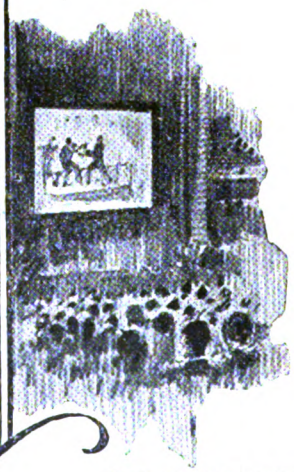

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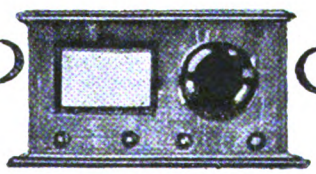

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The Official Organ of The Television Society

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Technical Editor: J. C. RENNIE, B.Sc., A.M.I.E.E.

Vol. II] AUGUST 1929 [No. 18

EDITORIAL

IN our last issue we were able to record the latest available information as to the favourable progress made by the Baird system of television in Germany. In the course of that report we described how a German broadcasting station is transmitting television daily, and how these transmissions are being successfully received at the Baird Company's laboratories just outside London, apparently without any interference being caused to other broadcasting services.

* * *

WE further drew attention to the fact that in accordance with the arrangements which have been made Germany has secured the honour of being the first country in Europe regularly to broadcast television, and we make no excuse for again pointing out that a British system is being employed.

ACCORDING to the latest reports from Germany all continues to go well, and the newly-formed German Television Company is rapidly getting into its stride with a view to placing instruments on the market in that country. This happy state of affairs (from the point of view of the German enthusiast) is due entirely to the vision, initiative and hearty co-operation which the German Government gave to the Baird Company, without which assistance these things could not have come to pass.

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* * *

IN violent contrast to this situation, we must survey the deplorable state of affairs in this country. Readers of TELEVISION are already familiar with the long struggle which has had to be fought in this country by the Baird Company in its efforts to obtain official recognition and broadcast facilities.

* * *

FROM time to time we have ourselves had occasion to make comparisons between the attitude towards television of the British authorities and that of broadcasting authorities of other lands; and in the interests of a British invention we have had good reason to criticise the attitude of both the Government and the

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B.B.C. As a result, however, of the intervention of Sir William Mitchell Thomson, the Postmaster-General of the late Government, who arranged for a test demonstration to be given by wireless through B.B.C. stations to himself and to a representative jury of members of Parliament (which was in every way highly successful) a more reasonable attitude came into being.

* * *

SIR William Mitchell Thomson indicated in a letter to the Baird Company that he was anxious that facilities should be afforded for continuous and progressive experiments of the Baird apparatus, provided that satisfactory terms were negotiated between the B.B.C. and the Baird Co.

* * *

AS a result of the late Postmaster-General's intervention it was confidently expected, when our last issue went to press, that television transmissions would commence in July. Those of our readers who have followed this controversy must have read with considerable surprise and indignation the report in the general press to the effect that the Baird Company had been obliged to break off negotiations with the B.B.C.

* * *

IT must be obvious to everyone that, whether the Baird system of television is, or is not, sound, practical, and possessed of definite entertainment value (matters which have formed the basis for a considerable amount of discussion), the one and only way to settle the matter is to refer it to the final arbiter in this country—Public Opinion.

* * *

THE only way in which the opinion of the public can be obtained on this subject is to give the public an opportunity of examining it, just as it was given an opportunity of examining sound broadcasting.

* * *

IN order that the man-in-the-street may be able to examine television the first requirement is that television shall be transmitted at frequent intervals at times when he is at liberty to study results. The second requirement is that apparatus should be placed at his disposal. This second requirement, although largely commercial, is as important as the first. Before the man-in-the-street can obtain apparatus somebody must manufacture it, and unless it is manufactured in considerable quantities that apparatus is going to prove expensive. Obviously, no manufacturer is going to embark upon a production programme until (1) there is a regular transmission service, (2) he is assured that that transmission service is going to continue unrestricted and undiminished for a certain definite period of years.

* * *

THESE are logical factors in a situation which must surely be apparent to anyone, whether he be an interested listener who is desirous of experimenting with television, an official of the B.B.C., or an official of the Government. But in spite of the obviousness of these things, what do we find? We find that as a result of Sir William Mitchell Thomson's action the negotiations between the Baird Company and the B.B.C. have come to nothing, the cause of the failure being that the B.B.C. in its wisdom considers that all aspects of the question can adequately be met by an offer to the Baird Company of three transmission periods per week of fifteen minutes each, commencing at 11 a.m. There is no guarantee that even these meagre facilities will continue to be granted for any definite length of time.

* * *

THE contrast between the treatment of a British invention in this country and the hearty welcome which it is receiving in other countries becomes more and more marked and lamentable.

* * *

THE B.B.C. was originally given its monopoly in order to assist it not only to give the British public the kind of entertainment which it wants, but also to assist scientific development relating to the art of broadcasting. There is abundant evidence, even from within, that the B.B.C. is misusing its monopoly on the entertainment side; and there is beginning to accumulate a quantity of evidence which seems to indicate that the B.B.C. is determined to use its monopoly not to develop but to throttle scientific development.

* * *

IN the light of these facts, we think it is time for the new Postmaster-General to consider seriously these misuses of the B.B.C. monopoly, and whether that body should not be reconstituted upon less autocratic lines.

* * *

Television in South Africa.

IN our last issue we announced that a delegation headed by Lord Angus Kennedy, the Vice-President of the Television Society, had left for South Africa to demonstrate the Baird system of television before members of the British Association, whose annual meeting is being held there this year. On going to press with this number we have received a cable from Lord Angus Kennedy stating that he was accorded a most cordial welcome on his arrival in Cape Town, and that the South African Broadcasting Company have placed their facilities at his disposal at either Cape Town or Johannesburg. According to the cable the apparatus which the delegation took out has already been installed within the precincts of Cape Town University.

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SCREENING IN WIRELESS RECEIVING APPARATUS

By R. L. SMITH-ROSE, D.Sc., Ph.D., A.M.I.E.E.

Modern research, stimulated by the demand for powerful amplifiers (both H.F. and L.F.) and complete receivers, has proved that one of the greatest obstacles in the path to success is the interaction which, unless guarded against, will inevitably take place between successive amplifying stages. The only effective way to eliminate interaction is to employ efficient screening. In the following article our contributor explains the causes of interaction and the various screening methods which have been used to overcome it.

THE great developments which have taken place in recent years in the technique of wireless reception have given rise to the need for a close scientific investigation of the problem of shielding one piece of electrical apparatus from another. The demands of improved apparatus for the reception of broadcasting, and more recently for picture-recording and television, can only be adequately met by the design of more sensitive, and yet stable, receivers giving greater and greater amplification.

Modern research has shown that the necessary amplification is only obtainable if the various stages are adequately screened from each other. In many cases it is also necessary wholly or partially to screen the complete receiver in order to avoid interference from stray fields due to electric supply mains or other sources of disturbance. It is, therefore, desirable that both the designer and user of modern receiving and recording apparatus should thoroughly understand the principles underlying electromagnetic screening in its various forms, and the methods by which this may most easily be applied to attain the desired object.

Electrostatic Screening.

The simplest type of screening is that known as electrostatic, since it deals with stationary electric charges and fields.

Ever since the earliest days of electricity it has been known that no charge is found inside a closed box of conducting material placed in a steady electric field. The classical experiment with "Faraday's Cage" provided a striking demonstration of this principle, and it is well known to all students of electricity.

Suppose that in Fig. 1 a positive charge at *A* is producing an electrostatic field at the apparatus *B*. If,

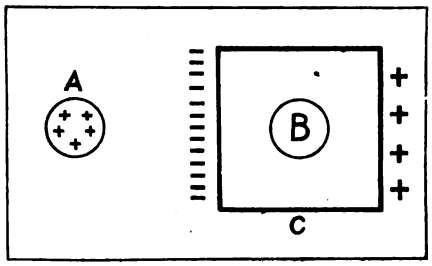

Fig. 1.

The induced charges on the shield C neutralise the effect of the charges at A on apparatus situated at B.

now *B* is surrounded by a metallic box *C*, induced charges will be set up on this box as indicated, and the electric field at *B* must now be calculated from the original charge *A* and the induced charges on the shield *C*. These induced charges are always such that the nett electric field inside the screen is zero, and we may therefore say that the inside of the box *C* is perfectly screened from the *static* charge at *A*.

Since all the charges under consideration are stationary, no currents will be flowing in the screening box *C* and, therefore, the resistance of the material of the box is not very important provided that it is sufficiently conducting to allow the induced charge to distribute itself freely. For similar reasons it is not essential for the material of the box to be continuous; a box of perforated sheet or copper gauze will still give the perfect screening required, since the induced charges can distribute themselves in such a way as to render the presence of the holes, if not too large, negligible.

If it is desired to connect the apparatus at *B* to earth then, as indicated in Fig. 2, charges may be induced from *A* in the connecting wire *D* and so be conducted to the apparatus *B*, which is evidently then not perfectly screened. To mitigate this trouble the earth connecting wire *D* must be connected to the screen at its point of entry *O*, when it becomes part of the screen *C*, and so *B* is once more completely protected. Continuous metallic box screens of this nature adequately connected to earth are sometimes employed for the protection of powder magazines and oil dumps from the effects of lightning discharges; for the building up of the charges prior to a flash usually takes place so slowly that the conditions approximate very closely to the electrostatic case.

Screening for High Frequency Impulses.

It will be noticed that in the cases so far considered the shielding is

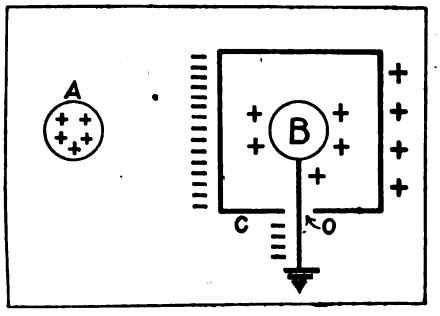

Fig. 2.

Illustrates the effect of making an earth connection to B. If the shielding action of C is to be maintained the earth wire must be connected to the screen at its point of entry O.

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accomplished by the combined action of the induced charges and the original charge. If instead of dealing with a steady charge at *A* we have a charge which is varying in magnitude,

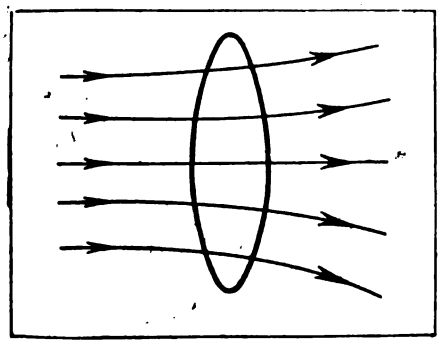

Fig. 3.

The magnetic field threading a closed conducting ring is opposed by the current which it induces in the ring.

with or without a change in sign, then the charge induced in the shield *C* will be continually varying and there will be a flow of current around the screen as the charges endeavour to accomodate themselves to the conditions required by the charge at *A*.

Thus, if the field produced at *B* by the charge at *A* is of an alternating nature, the shielding effect of the screen *C* will depend very much upon its conductivity, and as the frequency is raised so will the conductivity become the more important. For screening assemblies of apparatus or individual components from an alternating electric field in their neighbourhood it is thus necessary to surround them with a metallic screen of moderately high conductivity. This is the method adopted, for example, in the shielding of standard variable condensers to ensure that the capacity of the condenser at any reading of the scale shall be independent of the presence of any external fields or bodies.

In a similar manner a simple metallic plate screen has now become familiar in many designs of screened valve receiver, the intention being to ensure that the grid and filament end of the valve is efficiently screened from the anode end outside, as well as inside, the valve. In most cases, however, it is usually found that in either the audio or the radio-frequency end of a receiver such simple methods of screening are not sufficient, particularly when high amplification and sensitivity are required. Many cases of instability in a radio receiver can be traced to stray coupling between successive stages, a fault which can be completely cured only by effectively screening individual stages. In considering how to obtain adequate screening for practical purposes the action of the magnetic field, as well as that of the electric field, must be taken into account.

Electromagnetic Screening.

Suppose that we place a single closed loop of wire in an alternating magnetic field as depicted in Fig. 3. The elementary laws of electromagnetic induction can be applied to such a case and show that the result will be the flow of an induced current in the ring, which in turn produces a secondary magnetic field inside the ring in a direction opposite to that of the primary field. In normal cases in which the loop is reasonably small for the wave length employed and its resistance is low, this secondary magnetic field will tend to

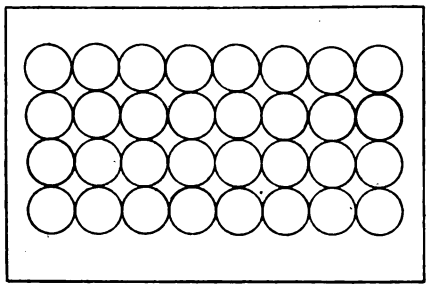

Fig. 4.

A series of rings arranged to screen a plane area from an alternating magnetic field.

eliminate the primary field within the ring, and to increase the field just outside the ring.

We have thus obtained a space within the ring which is "screened" from the effect of the original magnetic field. By placing a number of such loops side by side over a plane the dimensions of the screened area can be considerably increased (see Fig. 4). It will readily be seen that such a collection of loops can be replaced by a sheet of ordinary wire "rabbit netting." The efficiency of the screening will depend upon the stoutness of the wire and the mesh of the netting employed.

Now the reduction of the field by such a sheet extends only to a comparatively short distance on either side of the plane of the loops, for the path of the secondary field is only parallel to the primary field while actually passing through the sheet. On either side it tends to curve back on its return path although the distance at which such curvature becomes serious increases with the size of sheet employed.

Now supposing that instead of placing several loops side by side, as in Fig. 4, they were placed one behind the other on a common axis as in Fig. 5. It is now evident that the screened space comprises a cylinder enclosed by the rings, but—and this is the important point—the rings are only effective in neutralising a magnetic field which is perpendicular to their planes. For a magnetic field parallel to the plane of the loops no currents are induced in them and hence no reduction of the field can result.

A little consideration of this case will show that in order to screen a given space from an alternating magnetic field in any direction it is essential to have the space enclosed by a combination of three series of loops whose planes are mutually perpendicular to each other. Fig. 6 indicates a cube composed of three pairs of loops (*A*, *B*, and *C*) arranged mutually at right angles. In order to increase the dimensions of such a space each loop may be replaced by a sheet of gauze or netting.

The Screening of Large Spaces.

In the above manner one sees how a large space, such as a room or shed, can be shielded from an alternating magnetic field by surrounding it with a screen of wire gauze or netting. If, as is usual, the screen is made up with plane sides it is important that adjacent edges be well connected together, as otherwise one of the sets of loops becomes open-circuited, when its screening properties would disappear.

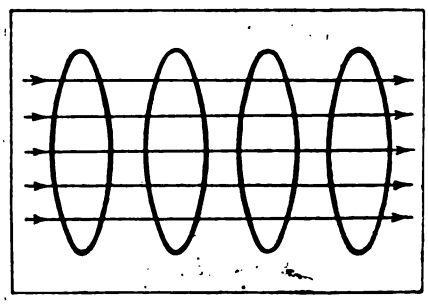

Fig. 5.

An arrangement of loops giving more effective screening for fields parallel to the axis of the loops.

For example, suppose a cube of netting is made up as in Fig. 7 with all edges efficiently joined or bonded except along *AG*. Then only the end

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surfaces of the cube are effective in screening fields perpendicular to *A B C D*, whereas by bonding the edge *AG* a very large number of intermediate loops is brought into action and the screening properties for such fields is much more efficient. This question of making adequate

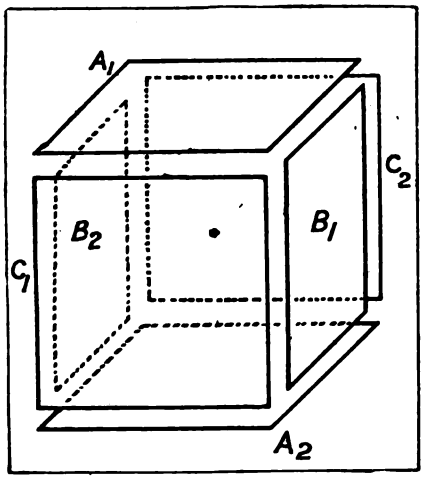

Fig. 6.
Six closed loops arranged mutually at right angles to screen a cubic space.

connection at all points which are to form part of conducting loops is found to be of the utmost importance in screening.

Here we have a type of screen which is in a very practicable form for the purpose of screening whole sets of receiving apparatus, for it is a comparatively simple matter to cover the whole of the inside of a receiving room with wire netting. For example, a wooden hut containing sets of receiving or measuring apparatus can be screened in this manner by simply lining the interior of the hut with wire netting. For most purposes the ordinary one inch mesh size will be suitable, but if greater efficiency of screening is required the additional cost of the half-inch or even smaller size may be justifiable.

How to Screen a Room.

The netting is simply attached as a lining to the interior (walls, floor and ceiling) of the hut or room, no insulation being required. The netting on the floor can be conveniently covered with linoleum to save wear on the wire, and also to facilitate sweeping the floor. Care must be taken to bond over the slits which will occur where adjacent strips of the netting meet, so as not to leave gaps in the conducting loops in any place. Windows can usually be covered over directly without any special modification.

In the case of doors, the whole wall containing the closed door can first be covered and then the netting can be slit round the door to permit of its opening. Since these slits will form only part of the wall, they will cause practically no loss of screening efficiency, but as an additional precaution a simple kind of spring contact can be arranged to short circuit the gap at frequent points around the door when it is closed.

The photograph reproduced in Fig. 8 shows a view of a room which has been completely screened with galvanised iron wire netting of half-inch mesh. Special spring clips are arranged around the door opening as shown, to ensure efficient contact, and care has been taken to keep all electric light wires, gas pipes, etc., outside the screen; for as explained in the early portion of this article, the screening properties of the cage will be spoiled if any metallic conductor is brought inside without being connected to the screen at its point of entry.

The room shown in Fig. 8 is used to contain a wireless receiver upon which overall performance measurements are being made, and it is necessary to shield the receiver from any outside interference. Tests carried out on a wave length of 360 metres have shown that the field inside this room is only 5 per cent. of that prevailing outside, so that the screen may be said to have an efficiency of 95 per cent.

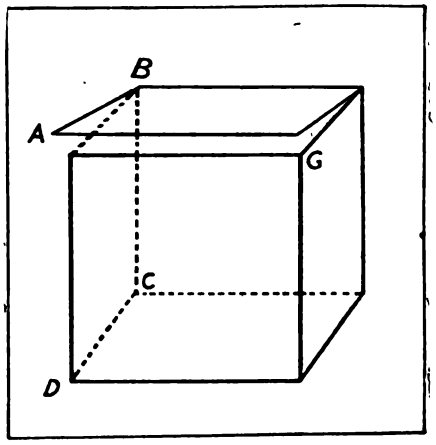

Fig. 7.
A faulty screen in which only the end surfaces are effective in screening fields perpendicular to A B C D. By bonding over the edge AG, many more loops are brought into action, and the screening is considerably improved.

The More Complete Screening of Smaller Spaces.

When, as frequently happens, it is required to reduce the field to less than 3 or 4 per cent. of its initial value, it is necessary to take many additional precautions. From the fact that the reduction of the size of

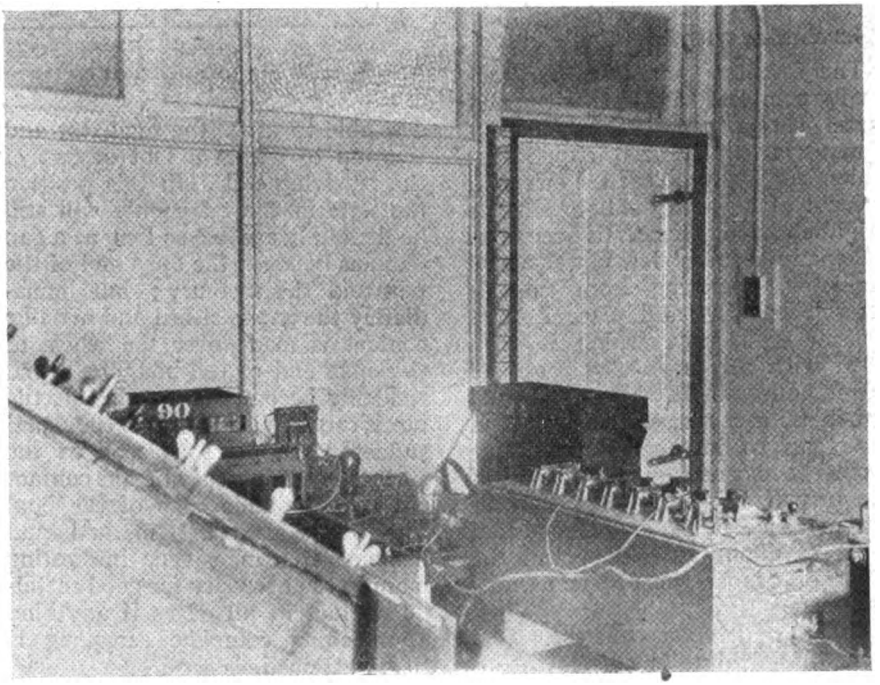

Fig. 8.
Photograph of an experimental room lined throughout with galvanised iron wire netting. On a wavelength of 360 metres the screening efficiency is about 95 per cent.

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mesh of the netting brings about a greater screening capability, one would expect, if the netting were replaced by a solid sheet of metal, a very great reduction in the field strength inside. Although it is not

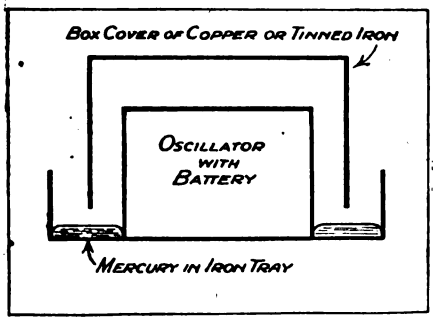

Fig. 9.
Experiment to show that screening is not complete until the screening box is quite closed by the mercury seal.

usual to require to screen large spaces in this drastic manner, the writer can recall one instance of a commercial receiving station in which the whole of the apparatus, except the frame aerial, was in a room lined completely with solid copper sheets, all joints being well sweated over and an elaborate contact arrangement being used at the door. This, however, represented a rather extreme case in which it was necessary to eliminate interference from a high-power spark transmitting station only a few miles away.

Screening with Metal Sheets.

The essential principles of practically complete screening with solid metal sheets can be very nicely demonstrated by an experiment which can easily be carried out with the aid of a valve oscillator in the neighbourhood of a sensitive receiver. Take any form of low-power valve oscillator, operating from, say, a six-volt battery, and place it in a shallow iron tray, which is then filled with mercury to a depth of about half-an-inch. Next construct two metallic boxes, without lids, and of a size to just easily cover the oscillator and rest on the bottom of the tray (see Fig. 9). One of these covers should be made of tinned iron sheet of about 2x gauge, and the other of copper sheet of the same thickness.

As the detector of the local oscillating field it is convenient to use a frame coil connected to a six-valve amplifier or to a supersonic heterodyne receiver. In either case some arrangement must be provided by which the set can be made to heterodyne the oscillations received from the oscillator in the tray as in the usual reception of continuous wave signals. With its cover removed, adjust the oscillator to function on a suitable wave length and tune in the resulting continuous wave on the receiver. It will probably be found that the resulting beat note is very loud and can be heard several yards from the telephones, even when the oscillator is placed at a distance of 100 ft. from the coil receiver.

An Interesting Experiment.

Now take the tinned iron box and place it gradually over the oscillator in the tray of mercury. As the box begins to envelop the oscillator it will be found that the intensity of the beat note in the telephones rapidly decreases, and it will be desirable to move the oscillator and tray up to within a foot or two of the receiving coil. In this position the note in the telephones will still be distinctly audible so long as a gap remains between the open end of the box and the mercury; but immediately the gap is closed and metallic contact is made over the whole of the open end of the box, the signal suddenly becomes inaudible. If the box is raised at one side only the signal suddenly reappears as soon as the surface of the mercury breaks contact with the metallic edge of the box. This effect is most marked and demonstrates in a very interesting manner the necessity for good metallic contact at all edges if anything approaching complete screening is to be attained.

A word of warning to the experimenter is necessary here, to the effect that mercury has a very destructive action on solder, and the seams of the boxes should be carefully inspected at times to make sure that they are still adhering together. A more satisfactory job for experiments of this nature is to utilise iron boxes with the joints welded over.

Copper not so Effective.

If now the iron box be removed and the copper box placed over the oscillator it will probably be found that the signal in the telephones can still be heard when the box is resting on the tray and its open end is immersed in the mercury to the depth of half-an-inch.

Similar results will be obtained if the oscillator is placed inside the box and a metallic lid is soldered down all round. Such experiments are rather laborious, but they are a good test of the skill of the tinsmith, since, in the case of the iron box, it will be found that a gap or a " dry soldered " joint as short as half-an-inch will make all the difference in the ability to detect an external field from the oscillator.

These experiments show, therefore, that it is only possible to screen a valve oscillator completely by placing it inside a sealed box of tinned-iron sheet of sufficient thickness to prevent

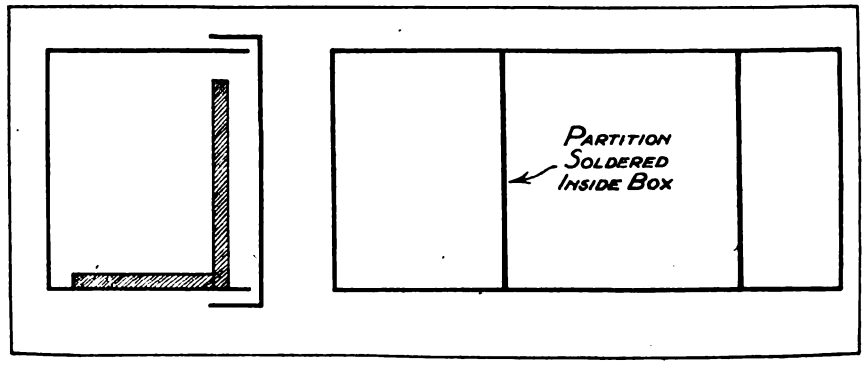

Fig. 10.
Screened box with partitions for inter-stage screening at radio or audio frequencies.

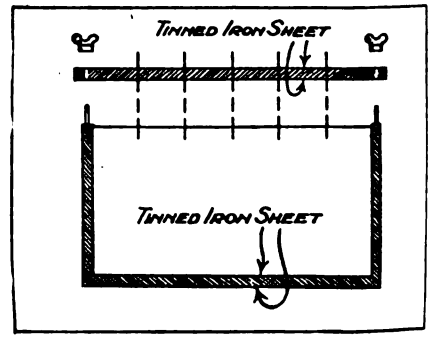

Fig. 11.
Screening box with close-fitting, bolted-down lid.

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the direct penetration of the high-frequency magnetic field through it. In this respect iron is found to be far superior to copper, a result which is in complete accordance with theory, for, in this case, the screening action is due to eddy currents, and the magnetic permeability of the material enters into the formula expressing the reduction in field strength.

Although it is very difficult to make quantitative measurements, it can be deduced that the somewhat drastic screening methods mentioned above result in a reduction of the field intensity to about one-millionth of its original value.

The Practical Design of Screening Boxes.

With the above explanation of the fundamental principles underlying the methods by which small spaces may be shielded from stray electro-magnetic fields, this article will conclude with a brief description of the simplest methods in which these ideas may be put into practical form.

During the past two or three years the growing demand for screening arrangements in the design of wireless receivers has led to corresponding developments on the manufacturing side. Whereas it was formerly necessary for the experimenter and research worker to make up his own screened boxes and compartments in a somewhat laborious manner from tinned iron sheet, it is now possible to select suitable boxes from a large range of manufactured sizes. It is also possible to obtain commercially a form of three-ply wood covered on one or both sides with sheet metal, from which very serviceable screened boxes can be constructed.

It is a comparatively simple matter to build a complete receiver inside such a box as suggested in the sketch in Fig. 10; while if interstage screening is desired partitions can be arranged within the box in a convenient manner. Screened valves can be incorporated in the design by the simple provision of a sliding door in the appropriate partition. In the ordinary way the lid of such a box will be one or two inches deep and will be just the usual tight fit.

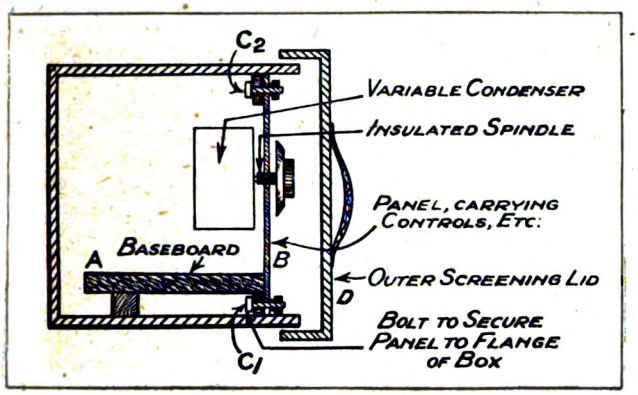

Fig. 12.

Section of screened receiver in which a metal panel B is used, bolted to a flange inside the screening box, as shown at C_1 and C_2. The receiver is mounted on the baseboard A and panel B, and an outer lid D fits overall.

Remembering what was said earlier in the article as to the dependence of the screening efficiency upon the good contact obtained all round the opening, it is obvious that the screening will be considerably improved if a flat lid is used and this is bolted down securely as illustrated in Fig. 11.

A Complete Box Screen.

The box containing the necessary apparatus to be screened is lined with tinned iron sheet inside and outside. In this instance it is important to secure a very well-finished plane surface to the open end of the box, and except at the corners where they are unavoidable, no joints should occur along this edge. The sheets of tinned iron should be carefully bent over the box edge and sweated together with a good quarter-inch overlap at a convenient point down the inside of the box. If desired, an inner, loosely fitting lid may be fitted to the box for the support of the components, controls, etc.

For the fitting of the main lid a number of No. 2 B.A. screwed rods

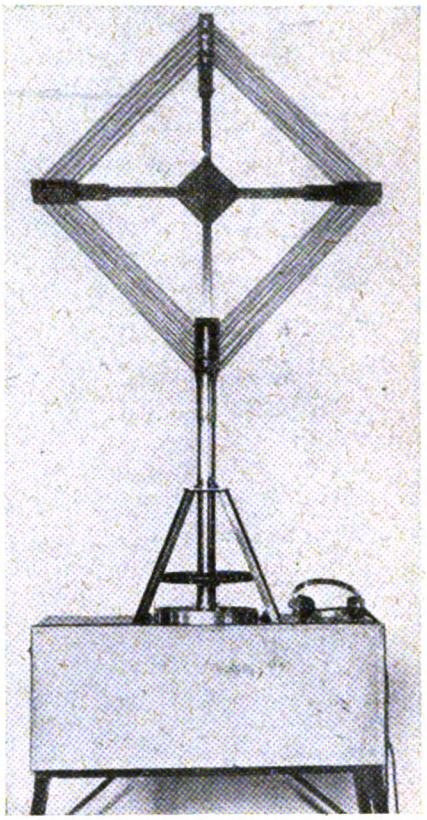

Fig. 14.

View of complete direction finder with outer screening lid in position.

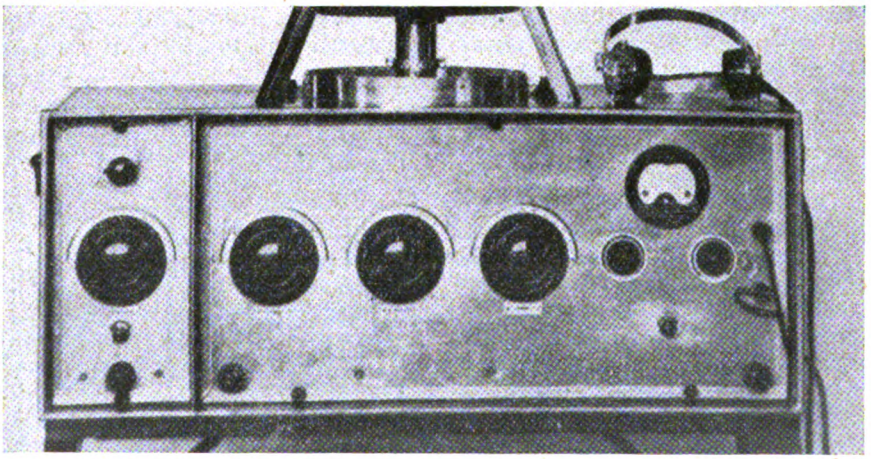

Fig. 13.

View of screened receiver sketched in Fig. 12, showing tuning controls, etc., mounted on the screening panel.

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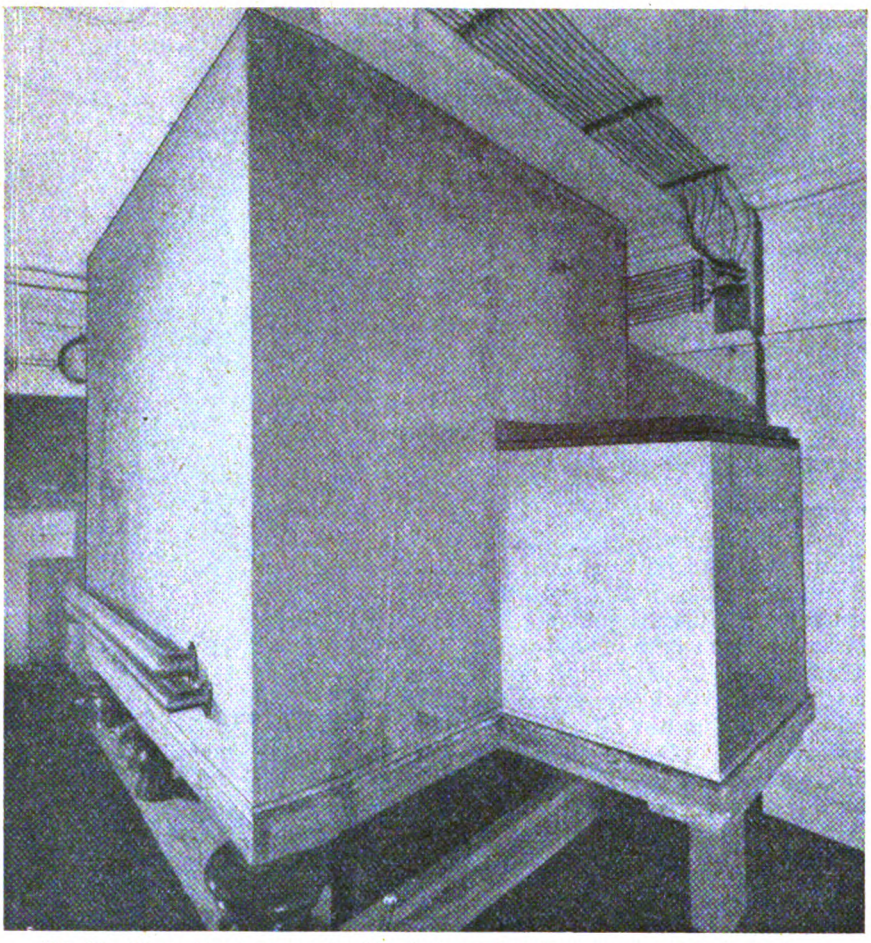

Fig. 15.—View of large screened cabin six feet cube with a mercury sealed trap door.

are let into the open edge of the box at distances of not more than 4 inches apart, as shown in Fig. 11. When they are fitted into position, these rods are all soldered to the covering of the box, being careful not to allow the solder to spoil the plane surface of the edge of the box. The lid of the box is simply a flat, well-made wooden panel, of $\frac{3}{8}$ inch to $\frac{1}{2}$ inch in thickness, and covered all over with tinned iron sheet. Great care must be taken to secure a good flat surface all round the edge where the lid is to make contact with the open top of the box. Holes are drilled at the requisite intervals at the edge of the lid to enable the latter to fit over the bolts fixed to the box.

After placing the apparatus inside the box and arranging any external controls in the manner described in connection with the previous design, the lid is fitted over the box and screwed down with wing nuts, as shown in Fig. 11. The most important details to be attended to in the construction of this type of box are: first, securing an accurate fit between the surfaces of the lid and the top edge of the box; and, secondly, screwing down the lid tightly to make efficient contact with the box at every possible point. If an oscillator is placed within the box and a frame coil receiver set up in the neighbourhood, as in the experiments previously described, the effect of screwing down the lid can be experienced with some quite surprising results. When the nuts are slack the placing of a heavy weight upon the lid will give a very noticeable drop in the strength of signal due to the stray field from the box, illustrating the importance of securing adequate contact between the box and its lid at all points.

Making Controls Accessible.

The chief difficulty in such an arrangement as that just described is that of bringing condenser controls etc., through the main lid. A convenient manner in which this may be overcome is illustrated in the sketch in Fig. 12, showing the method of screening the whole receiver of a portable wireless direction-finder. The whole of the receiver, including its associated batteries, is mounted on the base-board *A*, to which is screwed the vertical panel *B*, carrying the variable tuning condensers, filament resistances, potentiometer and a combined voltmeter and milli-ammeter.

This panel is constructed of plywood covered on both sides with metal sheet, and when the receiver is pushed home inside the screened box the panel can be bolted up tight to a flange soldered inside the box as indicated at C^1, C^2 in Fig. 12. It is evident that the spindles of the variable condensers, and also the filament resistances must be insulated from the panel, so that there is no lead passing from the inside to the outside of the box. In this case, when the panel is bolted up securely, the receiver it supports is moderately well screened, although all controls are accessible at the front of the box.

For still greater efficiency, however, a second outer lid is provided, which, as indicated at *D* in Fig. 12, is just an ordinary overall fit on the box. Fig. 13 shows the complete receiver with its external controls. The

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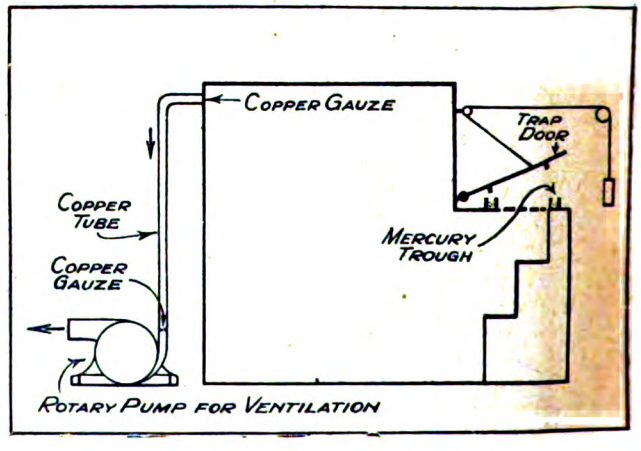

Fig. 16.
Sectional sketch of screened cabin showing arrangement of mercury sealed trap-door for entry, and rotary pump for forced ventilation.

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Sydney A. Moseley

And the Hidden Hand

READERS of this magazine may have been perturbed on reading in the newspapers certain disquieting statements regarding the position between the Baird Television Company and the British Broadcasting Corporation.

Just when one expected the *grand finale*, when the programme for the first broadcasting of television was expected, a statement of an altogether different character was issued to the Press. The announcement to many came as a thunderbolt, but to us who had been working behind the scenes it did not come altogether unexpectedly.

Those who have taken the trouble to read between the lines of my articles in TELEVISION may have gathered that influences have continually been working in the background with the object of retarding, if not holding up altogether, the progress of television, or, at any rate, *British* television.

It used to be customary during the war to talk of the Hidden Hand. A great deal of that was mere propaganda—or the result of a disordered imagination, but when I apply the term to the situation regarding television, I do so in all sincerity, and with a due consciousness of my responsibility.

One would have thought that after the jury of Members of Parliament, representing all parties of the House — an officially authorised body, suggested and chosen by a member of the late Government—the result of this jury's verdict would have been acted upon without hesitation by the British Broadcasting Corporation. A sense of fairness, if not a sense of public responsibility, should have dictated the next step, namely: to give the fullest facilities to the Baird Television Company for the inauguration of a public service.

Instead of that, the B.B.C., either from wilful misunderstanding of the situation, or a total lack of appreciation of realities, has seen fit to offer to the Baird Company facilities of an entirely inadequate character.

They offered the Baird Company a quarter of a hour three times a week, and with no guarantee of continuity.

In other words, the B.B.C. have trifled with the situation and, following the attitude adopted by them since the very beginning of negotiations, have literally snapped their fingers at the successful results of the demonstration given to the Postmaster-General's deputation of Members of Parliament. If the threat had been made that Government deputation or no Government deputation the B.B.C. would hold up this service as long as they possibly could, such a threat could not have been more efficiently carried out.

They are succeeding in doing so, but readers need not be unduly alarmed; *the position of the Baird Company, far from being weakened by this inexplicable attitude of the B.B.C., has been strengthened considerably in the course of the last few weeks.*

I have reason to know that when the announcement was made that the Baird Company had been so outraged by the offer of the B.B.C. as to break off negotiations with them directly, the effect upon the public mind was of a most disquieting kind.

Before an hour had passed after the announcement had been made public, the Postmaster-General was approached by many people who wished to know the reason why the B.B.C. was playing with this important matter.

Now the reader will naturally wish to know what effect the new Government has had on the course of negotiations. It will be remembered that Sir William Mitchell Thomson, the Postmaster-General in the last Government, made himself responsible for the announcement that facilities should be given for an experimental broadcasting service. It will be useful to reproduce the salient points of that historic comunication:

"The demonstration showed that the Baird system was capable on that occasion of producing with sufficient clearness to be recognised the features and movements of persons posed for the purpose at the transmitting point.

"The Postmaster-General is, however, anxious that facilities should be afforded, so far as is practicable without impairing the broadcasting service, *for continued and progressive experiments with the Baird apparatus*, and he would assent to a station of the British Broadcasting Corporation being utilised for this purpose outside broadcasting hours. He understands that the Corporation would agree in principle to this course, provided satisfactory terms were negotiated between the Corporation and the Baird Company."

The new Postmaster-General, Mr. H. B. Lees-Smith, is known to be a conscientious and painstaking man. The public will not forget the impression of independence and clear-thinking which he gave during the course of the protracted Savage

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enquiry. I have reason to know that the qualities which marked him out as a man of unusual strength of character are being brought to bear upon the present problem. He himself has called for the papers (and they are voluminous) and is giving them particular study.

Public Enquiry Wanted.

I expect, therefore, that before the next issue of TELEVISION appears, developments of a very interesting character will have occurred. But, personally, whatever happens (and whatever can happen must be of a favourable nature so far as television is concerned), I shall not rest content until a public enquiry has been set on foot to clear up many of the disturbing features in this long controversy. I am desirous that the whole situation as regards the launching of wireless pictures shall be explored—the association with this issue of a certain City Financial House, and whether the governors of the B.B.C. were fully aware of their responsibility, as the controllers of what is virtually a semi-government department, in permitting a letter from them granting facilities for the broadcasting of still pictures, etc., to be published in a prospectus appealing to the public for subscriptions.

Complete Reshuffle Necessary.

I have no comment to make in regard to the resignation of Capt. Eckersley from the British Broadcasting Corporation, but I should not be surprised if other resignations followed before very long. Indeed, apart from the extraordinary circumstances that surround the case of television, other matters in regard to the B.B.C. need enquiring into. In my view, a complete re-shuffling is needed. Savoy Hill has hardly a friend these days.

You will recollect that, in writing from Germany, I contrasted the spirit shown there with the spirit shown here at home. The German Company, of which the Baird Company is a member, has got into stride already, and is now in the course of manufacturing many thousands of sets. Here in England, where the cry is for more employment, production is being held up because of the obstinacy of the B.B.C. It should be obvious to the meanest intelligence that British manufacturers are not going to enter into mass production of "televisors" unless they have a guarantee that the service shall be continuous and have an opportunity of developing for several years.

There is much more I could write. There is the question of America. If what I hear is true then the need for this public enquiry which I have urged again and again becomes even more urgent.

The whole facts disclose a scandalous state of affairs which no Englishman will tolerate, and I repeat that I may be reduced to the length of publishing the whole story, and risk the inconvenience of a libel action.

In the interests of truth I have risked this inconvenience before, and I firmly assert that I shall not hesitate to do the same thing again if it becomes necessary.

Nevertheless, despite all, I am yet reluctant to abandon my desperately held pinnacle of peace. Let there be a change of heart (*or a change of personnel as is most likely*) at Savoy Hill and I shall be the first to move half-way to shake hands.

Apparatus Received

From Messrs. Gambrell Radio, Limited, we have received samples of their new Gam-brell Voluvernia Volume Control and Gam-brell Twin Fuse Unit.

The new Voluvernia is a great improvement on the first one. The construction of the present model enables the user to obtain a much smoother movement and a more even graduation of volume, which must be tried to be appreciated. The resistance is now 0 to ½ megohm, which appears to be that preferred by most experimenters for all-round purposes.

The Twin Fuse Unit for fitting in Mains Receivers and Battery Eliminator Units has already become fairly popular, but there is no doubt that in this new moulded form it will meet with the approval of the most particular. Even though the fuses are removed with the current flowing (which is, of course, undesirable), it is quite impossible to receive a shock. All contacts are positive.

Both components are excellent examples of what can be achieved in neatness, solid construction and efficiency in small articles of this order.

Broadcast of the Westminster Abbey Thanksgiving Service

RELAY TO CANADA AND AUSTRALIA BY BEAM TELEPHONY

The thanksgiving service in Westminster Abbey on July 7th was successfully broadcast throughout Canada and Australia by means of the Marconi - Mathieu multiplex system of telephony installed in the Beam station at Bodmin.

This installation had previously been used for a series of successful telephony tests to Canada, but had not hitherto been employed for broadcasting.

The reports received from Canada and Australia show that the transmission was clearly heard in the Dominion and the Commonwealth.

The service was transmitted to Bodmin by Post Office landline, and it was then sent over the Marconi-Mathieu multiplex circuit to Canada. In Canada the transmission was carried out by the Canadian National Railway Company's and the Canadian Marconi Company's broadcasting stations.

The Canadian Marconi Company's Beam station was used to relay the transmission across the Pacific to La Perousse, Sydney. From Sydney it was re-broadcast throughout Australia and to neighbouring countries by the stations of Amalgamated Wireless (Australasia), Limited.

It is on such national occasions as this that the immense value of *sight* is made apparent. To those stationed throughout the far-flung outposts of our Empire the stupendous possibilities of television are more quickly realised.

How much longer are they to be denied the use of this British invention?

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Speed Control of Electric Motors

By CYRIL SYLVESTER, A.M.I.E.E., A.M.I.Mech. E.

Television mechanisms, as at present developed, are driven by electric motors, and for successful results it is essential for both transmitter and receiver motors to run at precisely the same speed. This problem of synchronism introduces many difficulties, some of which are outlined in the following article.

IN a general way an electric motor is looked upon as a means of converting electrical energy into mechanical energy. Its function is to do work, to develop a certain amount of power. For ordinary purposes consideration of initial motor speed is not an essential; the desired speed of the apparatus to be operated can be regulated by fitting large or small pinions or pulleys on the motor shaft; slight variations in speed will make little or no difference to the efficiency of the operations to be carried out.

The progress of science in certain directions, however, has made it necessary, where an electric motor is depended upon to perform important functions, that the speed should be regulated or controlled within very fine limits. Some of the conditions which come readily to my mind are radio transmission, mechanised music, talking films, and last, but by no means least, the broadcasting of scenes and objects by television.

Although in the early days of television development a motor was looked upon as a means to an end (to rotate the discs at a more or less constant speed), it is now found that the speed must be capable of control within very fine limits; a few "revs." more or less per minute will make all the difference to the success or failure of experiments or a transmission.

All electric motors are rated at a certain h.p. at a certain speed. In a fractional horse-power motor, for instance (such as would be used for operating television apparatus), of 0·75 h.p., the speed may be stated to be 750 r.p.m. This means that the motor is capable of developing 0·75 h.p. at 750 r.p.m. It does not follow that the speed will be 750 r.p.m. at 0·25 or 0·5 h.p. It will, in fact, as I will show later, be considerably higher. If, therefore, the size of pinions and spur wheels are calculated from normal speed (full load speed) and the power for which the motor is rated is not developed, the speed will not be as anticipated. The essential here, then, is to control the speed so that a fixed speed at all loads can be obtained.

A general conception of motor speed control consists of inserting a resistance in series with the motor. The obvious result is that a certain amount of power (watts) is lost in the resistance, and this has the effect of

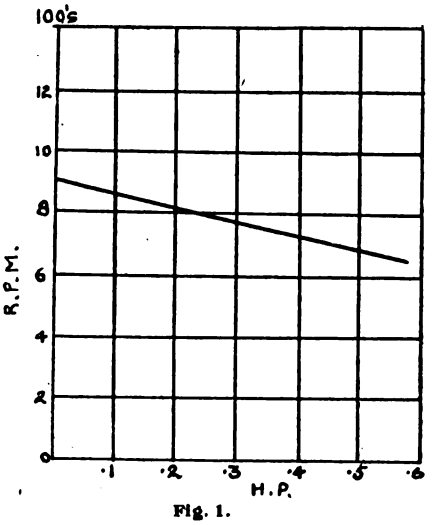

Fig. 1.

reducing the applied voltage to such an extent that a decrease of speed results. Such an arrangement is not satisfactory, since the control is limited in two ways: (1) The maximum speed is the speed on minimum load, and (2) the minimum speed will depend upon the load to be developed. It will be obvious that speed above normal full load speed is impossible. I will discuss these points.

Motors for direct current operation will be either shunt or series wound; compound wound motors would not be suitable for television purposes owing to the more or less constant character of the load. The characteristics of a shunt motor are illustrated in Fig. 1; this graph illustrates h.p. plotted against speed in r.p.m. It will be seen that on no load the speed is higher than on full load. The reason is that the effect of increasing the load is to slow down the machine slightly, and thus decrease the back e.m.f., the flux of the main pole pieces remaining almost constant. Between no load and any load developed by an electric motor we have three factors: the applied pressure, the back e.m.f., and the current through the armature. The applied pressure is constant so that, when the back e.m.f. is reduced, the current will increase in value.

From these considerations we can write—

$$E = e + Ir$$

where E is the applied pressure, e the back e.m.f., I the armature current, and r the resistance of the armature.

From this we get—

$$I = \frac{E - e}{r}.$$

The latter expression means that if the back e.m.f. decreases while E and r remain constant, the current I through the armature increases. When the current has increased to such a value as will enable the motor to deal with the increased load, the speed remains constant at its slightly reduced value, and the current also becomes steady.

With regard to the minimum speed (obtained through the insertion of resistance in series with the line) it should be remembered that the applied pressure, E, is absorbed in the resistance *and* in the motor. Let us assume that the resistance inserted has a value of six ohms, and that the current through the motor is five amperes, the volts lost in the resistance is—

$$E = I \times R = 5 \times 6 = 30 \text{ volts.}$$

If, therefore, the applied pressure is 110 volts, the pressure at the motor terminals will be—

$$110 - 30 = 80 \text{ volts.}$$

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Now h.p. is calculated in watts, so that, at decreased speed and full load armature current, the power developed by the motor is limited.

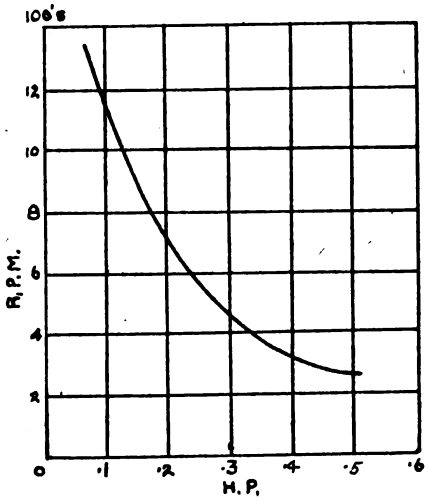

Fig. 2.

In the example I have quoted the rated watts will be $110 \times 5 = 550$ watts. With the decreased speed the watts input will be $80 \times 5 = 400$ watts; this is more than 20 per cent. decrease in power. The effect is that, if the work demanded of the motor is nearly full load, the armature would take more than full load current, which would be dangerous, and the speed would be much lower than anticipated owing to further decreases in back e.m.f.

In Fig. 2 is illustrated the speed characteristic of a series motor. In this type of motor the main pole pieces are energised by series coils which are connected in series with the motor armature; it follows, therefore, that the series coils will carry armature current, and, owing to the back e.m.f., the speed will depend upon the value of the current in the series coils and, therefore, upon the load developed. From the curve it will be seen that the speed increases with a decrease of load, the rate of increase becoming greater as the load is decreased. If the load were taken off altogether the armature would "race," that is it would attain such a high speed as to be dangerous.

I will now deal with efficient methods of speed control for both shunt and series motors.

The only method of reducing the speed of a motor at rated voltage is to insert resistance in series with it; this applies equally to shunt and series machines. The same effect can of course be obtained by reducing the applied pressure; this, however, is not always practicable. In a selection of a motor, therefore, the minimum speed, after the size of pinions and spur wheels have been determined, should be considered. That is, assuming a minimum disc speed of 5,000 r.p.m., with a 5 to 1 pinion and spur wheel ratio the speed of the motor would be 1,000 r.p.m. Increases of speed can be obtained with very small losses.

The speed of a shunt motor can be increased by inserting resistance in series with the shunt field winding. This reduces the shunt field current, which, in turn, reduces the strength or density of the lines of force. A schematic diagram of connections is illustrated in Fig. 3. Here, R is the resistance in the form of a rheostat, S is the shunt field winding, and A is the armature. Consideration of this diagram is necessary when "visualising" what occurs in the machine.

I have pointed out that the current in the armature depends upon the difference between the back e.m.f. and the applied e.m.f., and the back e.m.f. depends upon the rate at

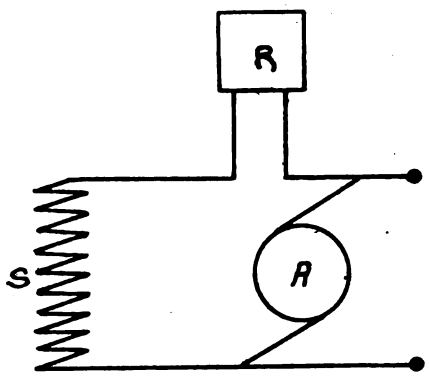

Fig. 3.

which the armature conductors cut the lines of force produced by the shunt field winding. With a strong field the armature conductors, to produce a certain back e.m.f. at a certain speed, will cut the lines of force at a certain rate. If the field strength is decreased, it means that the armature conductors must rotate at a greater rate if the same back e.m.f. is to be generated.

The effect of weakening the field is also to increase the current through the armature. This increases the lines of force round the armature conductors so that the attraction and repulsion is greater, and the armature proceeds in the direction of rotation at a greater rate. The losses in the field rheostat are very small because the shunt field current is also small. This can be seen by simple calculation.

Let us assume the resistance of a shunt field winding to be 100 ohms on 110 volts. The shunt field current will be—

$$I = \frac{E}{R} = \frac{110}{100} = 1{\cdot}1 \text{ amperes.}$$

The insertion of 20 ohms resistance, 20 per cent. of the total resistance, reduces the current to—

$$I = \frac{E}{R} = \frac{110}{120} = 0{\cdot}91 \text{ amperes.}$$

The volts lost $= 0{\cdot}91 \times 20 = 18{\cdot}2$ volts. and the watts lost $= 18{\cdot}2 \times 0{\cdot}91 = 16{\cdot}6$ watts (approx.).

The same reasoning follows when considering the speed control of a series motor; the field strength must be reduced. Since, however, the armature is in series with the series winding, it is not at once apparent how the field can be weakened. The conventional method of doing this is illustrated in Fig. 4. Here, S is the series field, R the rheostat, and A is the armature. It will be seen that the rheostat is in *parallel* with the series field winding and that this combination is in series with the armature. This arrangement permits a portion of the original field current to be shunted.

The rheostat is designed so that a permanent resistance is always in parallel with the field winding. This precaution is necessary because, if it were possible to cut out the whole of the resistance, the winding would be short-circuited and excessive (in fact dangerous) current would pass through the armature. With minimum resistance in parallel the field is weakest, so that with the maximum resistance inserted the speed will be lowest. Consideration of Fig. 4 also shows how, with increased speed, the

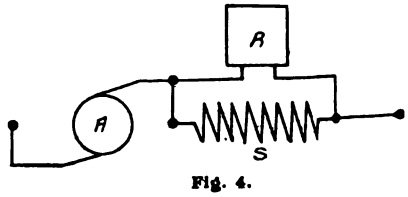

Fig. 4.

current through the armature is increased.

In conclusion I would say that field rheostats should be carefully designed.

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Aberrations of Lenses and Optical Systems

Part XIII

By Professor CHESHIRE, C.B.E., A.R.C.S., F.I.P.

WE have, in our work so far, confined our attention almost entirely to the action of thin lenses of small angular aperture, working in monochromatic light. These assumptions have enabled us to establish quite simply a number of basic facts and formulæ, but it must at once be admitted that, strictly speaking, a lens, however simple, can do nothing *quite* right.

This statement is true even of Nature's greatest optical triumph—the human eye, for Helmholtz, more than sixty years ago, shocked a great many people by boldly announcing in a lecture on "The Eye as an Optical Instrument":—

> "Now, it is not too much to say that if an optician wanted to sell me an instrument which had all these defects, I should think myself quite justified in blaming his carelessness in the strongest terms, and giving him back his instrument."

Later in the same lecture, after dealing with the various defects of the eye, he summarises the matter by saying that—

> "The adaptation of the eye to its function is, therefore, most complete, and is seen in the very limits which are set to its defects."

The conditions which a perfect optical system must satisfy have been laid down by Prof. Lummer in the following words:—*

> "The two regions of space in front of the lens and behind it must be in *collinear* relation—that is to say, all rays proceeding from a point in one region must unite again in a corresponding point in the other region, in such a way, in fact, that any extended geometrical form in the object-space in front, is precisely correlated to a similar geometrical form, in the image space behind the lens."

It is a curious fact that the only optical system which satisfies the conditions for a perfect system laid down by Lummer is the plane reflector, or looking-glass. The object in front of such a reflector is accurately imaged, point by point, under the law that any given point of the object and its image are found in the same normal to the surface of the reflector, and at equal and opposite distances from that surface. The object and its image are thus geometrically similar, but the image is reversed left for right, and unfortunately it is a virtual one.

The pinhole camera, again, gives a true geometrical projection of an object, and if the latter occurs in a plane it gives a similar and it may be a magnified image in a parallel plane. The beautiful and distortionless pictures of architectural subjects produced by a pinhole are well known to photographers.

Smoke - Box Experiments. — The smoke-box (Fig. 1) provides us with a simple and fascinating method of studying the aberrations of lenses.

To construct such a box is an easy matter: take any old box about 8 inches wide, 8 inches deep, and about 2 feet long, and fit it with a glass top. (The box is shown standing on its side in the figure.) The end *A* of the box should have a circular hole cut in it to receive a large lens of from 4 to 5 inches in diameter, and with a short focal-length. A plano-convex lens, such as it used in a projecting lantern, will do admirably, and it can be purchased for a few pence.

Fix the lens in the hole in the end *A*, together with a cardboard template, such as is shown at *C*, Fig. 1. Two or three of these templates should be cut circularly to fit the recess in the end *A*, and punched with quarter- to half-inch holes, as desired, to limit the beams, the paths of which it is desired to study. The disc or template shown has five holes in a vertical diameter, and a similar number in a horizontal diameter. Any of these holes may be stopped

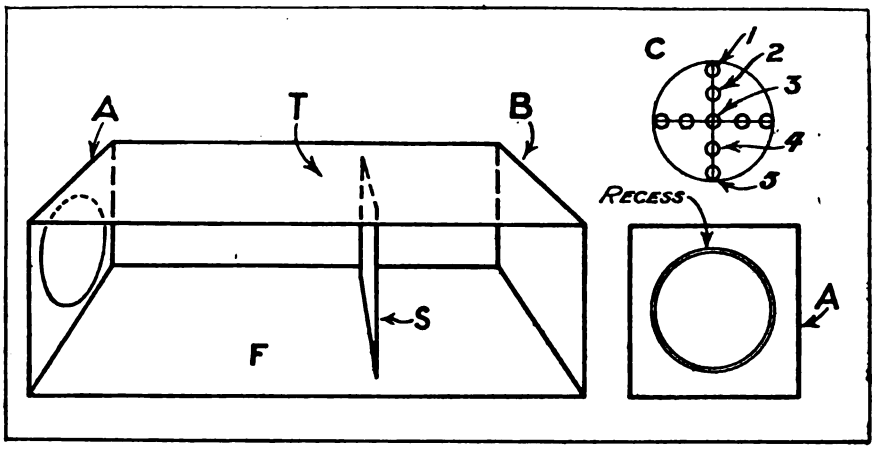

Fig. 1.
Smoke-box.

* See Lummer's "Photographic Optics," translated by the late Prof. S. P. Thompson, published by Macmillan and Co. 1900.

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out temporarily, or they may be covered by colour filters of glass or gelatine.

The brightest source of light available—an arc light is the ideal—should be placed at *E* (Fig. 2). An incandescent gas-mantle behind a half-inch hole in a sheet of tin does very well.

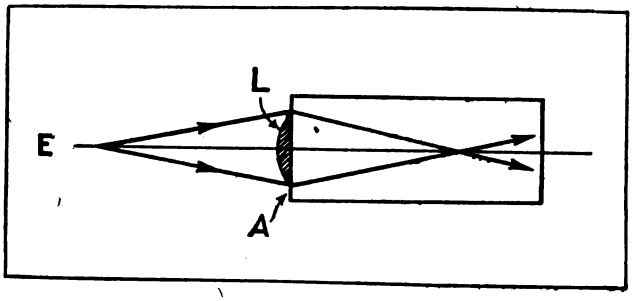

Fig. 2.
Diagram of the action of a smoke-box.

Lenses suffer from a number of aberrations, but for the present we will limit our attention to the two best-known ones—spherical and chromatic aberration, in each case, for a source of light on the axis of the lens.

Spherical Aberration.

Experiment 1.—Take the disc *C* and stop up all the holes except the centre one (3). Place a piece of red glass or gelatine in front of 3, and drop the disc *C* into the recess in the hole in *A*, and fix the lens *L* in front of it. Fill the box with smoke from a cigarette, having previously fitted a paper screen *S* in the box capable of being adjusted in position from the outside. Upon placing the source of light at *E*, the red light, more or less monochromatic, passes through the hole 3, and can be brought to a focus, either in a cloud of smoke, or on the screen *S*. Note the position of the screen.

Experiment 2.—Stop all the holes in *C*, except 2 and 4, and fit these with red filters. Focus the two beams on the screen *S*, and note that the latter is sensibly nearer to the lens *L* than in the first experiment.

Experiment 3.—Now stop all the holes except 1 and 5. Fit these with red filters and again focus on *S*. The focus is now nearer to the lens *L* than in experiment 2.

The results of our experiments are shown diagrammatically by Fig. 3. The rays close to the axis, passing through the aperture 3, are brought to a focus at i_1; those passing through the holes 2 and 4 are focussed at i_2; and those passing through the marginal holes 1 and 5 are focussed at i_3.

These experiments show us that in the case of a simple lens of appreciable aperture, even when using monochromatic light, successive zones, as they increase in diameter, bring the light to a focus nearer and nearer to the lens.

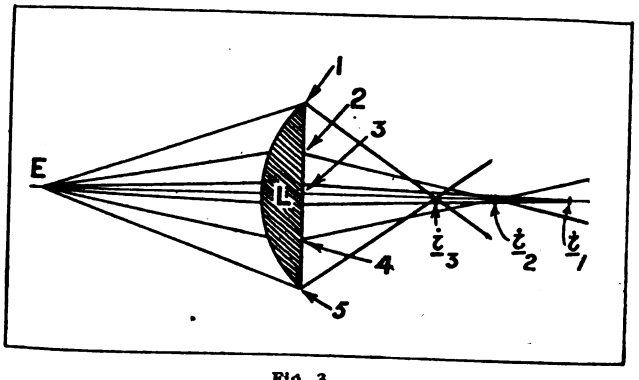

Fig. 3.
Diagram showing the spherical aberration of a simple lens.

Chromatic Aberration.

Repeat experiment 1 above, using hole 3, and red, green, and blue filters in succession. Green light being more refrangible than red, and blue light more refrangible than green, the focus for red occurs the furthest away from the lens, and that for blue the nearest. Confirm by using the holes 2 and 4 only, covering each in turn with (1), a red filter; (2), a green filter; and (3), a blue filter.

A diagram showing the experimental results is shown by Fig. 4.

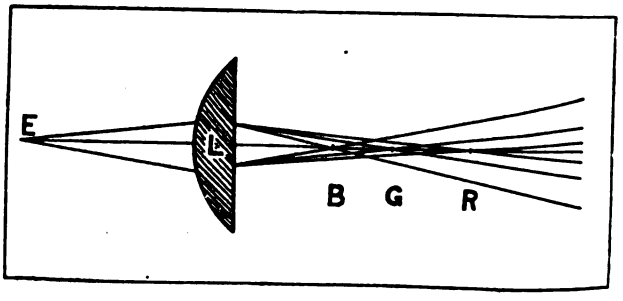

Fig. 4.
Chromatic aberration of simple lens.

A great stride has been made of late years in England in the application of what are known as "interference methods of testing" to the determination and measurement of the aberrations of lens systems. This work, now world-famous, we propose to deal with in our next article. As an introduction to it we will determine, by a simple application of the wave-method, the influence of the refractive index of the glass of a lens, upon the focal-power of that lens, and in doing so incidentally derive an important equation.

Imagine a lens *L* (Fig. 5) bringing light-waves from a distant point on its axis, such as a star, to a focus at the point *F*, also on the axis of the lens. As has already been explained in an earlier article (see TELEVISION for November, 1928), the function of a lens, stated in wave terminology, is to cut out a disc or calotte from each wave-surface that strikes it, and pass it on with altered curvature. Thus each of the waves acted upon by the lens in Fig. 5 may be looked upon as passing from a plane disc in the plane *AB*, in contact with the first vertex *V* of the lens, into a spherical disc $A_1 V_1 B_1$, in contact with the second vertex V_1.

It is evident, therefore, that whilst the edge of each wave-surface, disc, or calotte passes from *A* to A_1, in air, the centre of the disc will pass from *V* to V_1, on the axis of the lens; in other words, a little element or bit of a wave-surface at *A* passes to A_1 in air—the thickness of the glass being negligible—whilst a second little element passes from *V* to V_1 in glass.

Again we know that the refractive index *n*, for the glass tells us that

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light waves travel in glass with $1/n$th of their speed in air (or vacuum), so that the length of a glass-path must be multiplied by n, to give the corresponding length of the air-path traversed by a wave in the same time.

Finally, then, if a wave starting from a point (the object-point) on the axis of a lens, after refraction by that lens passes accurately through a second point (the image-point), it follows that all the elements of the wave surface pass from one point to the other in the same time, no matter what the actual path; in other words, the sum of the length of the air-path, added to n times the length of the glass-path for any one element, is equal to that of any other element. All possible routes are of the same length in *time*. The *optical lengths* are all equal.

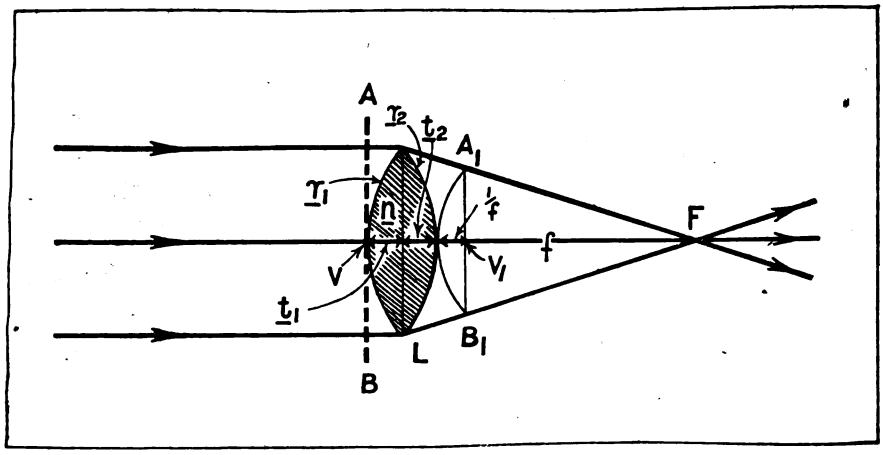

Fig. 5.
Diagram of the action of a lens on light waves.

Now let us return to Fig. 5 with our new knowledge. The optical length of the all-air route from A to A_1 must be equal to that of the all-glass route V to V_1, so that assuming that the wave at A passes to the point A_1, along a straight line parallel to the axis of the lens, as we are justified in doing if the angular apertures are small, we have—

$$t_1+t_2+\frac{1}{f}=n\,(t_1+t_2) \quad \ldots \quad (1)$$

But $t_1=\frac{1}{r_1}$, the curvature of the first surface of the lens, and t_2 equals $\frac{1}{r_2}$, that of the second, so that—

$$\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{f}=n\left(\frac{1}{r_1}+\frac{1}{r_2}\right)$$

or

$$\frac{1}{f}=(n-1)\left(\frac{1}{r_1}+\frac{1}{r_2}\right) \quad \ldots \quad (2)$$

An important result.

Examples.

(1) What is the focal length of a lens, made of crown-glass, for which $n=1{\cdot}5$, the radius of curvature of the first surface being 10 inches and the second surface being flat? Here—

$$\frac{1}{f}=(1{\cdot}5-1)\left(\frac{1}{10}+0\right)$$

Whence $f=20$ inches.

(2) In the case of an equi-biconvex lens of crown-glass and a radius of curvature for each face of 10 inches—

$$f=(1{\cdot}5-1)\left(\frac{1}{10}+\frac{1}{10}\right)$$
$$=10 \text{ inches.}$$

By the use of flint glass, with a greater n-value, it will be seen, the focal power $(1/f)$ is increased and the focal-length correspondingly shortened.

The Mullard Wireless Service Company, Ltd.
The Mullard Radio Valve Company, Ltd.

Arrangements have been made for Mr. S. R. Mullard to relinquish his position as Managing Director of the above companies in order to devote more of his time to other interests. Mr. Mullard will retain his office as Chairman of the Mullard Wireless Service Company, Ltd., and Director of the Mullard Radio Valve Company, Ltd., and will be General Adviser to the companies.

Screening in Wireless Receiving Apparatus (*concluded from p. 282*).

photograph in Fig. 14 shows the completed direction-finder with the outer lid in position and ready for operation.

While one or other of the arrangements suggested above will usually be found to be suitable for experimental purposes, it may sometimes be found that extreme screening efficiency is required without the inaccessibility attendant upon the use of nuts and bolts. In such circumstances it is possible to arrange the receiver inside a box, the lid of which is closed by a mercury seal, as indicated in Fig. 9.

To avoid using an excessive quantity of mercury this can be contained in a narrow trough along the edge of the tray, and the lid drops into this trough to complete the sealing of the box.

The photograph in Fig. 15 shows a large cabin, 6 feet cube, which is lined overall with tinned sheet iron. This cabin is provided with a mercury-sealed lid at the side, as shown in the sketch in Fig. 16, by which an operator can enter the cabin and seal it up afterwards by closing the trap-door lid. Such an arrangement provides a room suitable for an experimenter to work in, practically completely shielded from external interference. Naturally, special arrangements have to be provided for ventilation purposes, which are carried out by means of an electrically driven blower supplying air through a long copper tube covered with fine mesh copper gauze at each end.

In concluding this article a useful hint may be conveyed to the experimenter who is desirous of reducing to the minimum the stray pick-up of signal electro-motive-force on his receiving apparatus. Since the magnetic field in wireless waves is, for all practical purposes, horizontal, any coil or loop of wire forming part of a receiving circuit will have a maximum electromotive force induced in it when its plane is vertical, and zero electromotive force induced in it when its plane is horizontal. It is, therefore, advisable to arrange all such coils and loops of wire in a horizontal plane. While this applies particularly to coupling coils, which are frequently arranged with the plane of the windings vertical, it should also be observed in regard to the remainder of the high-frequency circuit.

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The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

PART VIII.—ENTER MARCONI.

WE have seen how, between November 1887 and December 1889, Heinrich Hertz, of Germany, astounded the scientific world by publishing the results of his experiments. These results proved not only the existence of wireless waves, but demonstrated all the laws concerning them which Clerk Maxwell, of Scotland, had predicted fifteen years before, and we have seen how these discoveries became at once the subject of experiments in many laboratories throughout the world.

Guglielmo Marconi.

Amongst the experimenters who were quick to pursue the subject was Augusto Righi, Professor of Physics at the University of Bologna, and amongst his pupils was Guglielmo Marconi, who had been born in Bologna in 1874. His father was a wealthy Italian, and his mother was a member of a well-known Irish family.

Marconi was only fifteen years old when Hertz completed the publication of his famous series of experiments. He was at once fascinated by this discovery of electric waves, and he soon had the idea—or, to quote his own words—"I might almost say the intuition, that these waves might, in a not distant future, furnish mankind with a new and powerful means of communication." This may have been the first time that Marconi had an "intuition" about wireless waves, but it was certainly not the last. Indeed, this instinctive fore-knowledge, which we call intuition, has been one of the most outstanding qualities displayed by Marconi throughout his life work in the sphere of wireless communication, and, luckily for the development of the art, it has, in his case, always been linked with extraordinary determination and unquenchable enthusiasm.

"I could scarcely conceive," he says, "that it was possible that their application to useful purposes could have escaped the notice of eminent scientists." But so it was. The boy had seen in a flash what remained unseen to all those great scientists who had been working on the fringe of the subject for several years. As Sir William Preece said, "They all knew the egg, but Marconi showed them how to make it stand on end."

First Experiments.

Marconi commenced, in 1895, at his father's country house at Pontecchio, the experiments which he has continued to the present day. His transmitter was a multiple spark gap as used by Righi, an induction coil, and a Morse signalling key. His receiver was a coherer as used by Branly, the filings being decohered by taps from the hammer of an electric bell, and the local circuit was closed by a relay, as used by Popoff. All the instruments, however, were improved in detail by Marconi, and, towards the end of these first experiments, he broke new ground by connecting one side of the spark gap to an aerial wire, and the

Marquis Marconi, with some of his early apparatus. On his left is a spark coil transmitter, and on his right the sensitive tube receiver and tape machine.

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other side to earth, thus producing for the first time a practical system of wireless signalling.

Early in 1896, Marconi succeeded in transmitting signals over a distance of two miles, and it is interesting to note that in August of the same year

HISTORICAL MARCONI APPARATUS.
This experimental tuned circuit was made by Marconi, and consists of a Leyden Jar condenser, a spark gap of two brass balls, and an inductance wound on the outside of the wooden former.

Commander Henry Jackson, R.N., who at that time was working quite independently and knew nothing of the work of Marconi, transmitted messages between warships.*

This pioneer work of Admiral of the Fleet Sir Henry Jackson, who was First Sea Lord in the War and is now Chairman of the Radio Research Board, was hidden at the time in confidential reports, and indeed was hardly recognised publicly until 1926, when the Royal Society awarded him the Hughes Medal "for his pioneer work in radio-telegraphy and its application to navigation."

Marconi Comes to England.

In 1896 Marconi brought his apparatus to England, and on June 2nd applied for provisional protection for his invention. In the following month he got in touch with Sir William Preece, Engineer-in-Chief of the Post Office, whom we have already mentioned as one of the early pioneers in this country. Preece at once recognised the genius of Marconi, and it was largely through his influential support that Marconi was received in this country with open arms, and given every facility for the development of his invention.

Marconi's first experiments in England were made between a room in the General Post Office in London and the roof of a building which was 100 yards distant. Later he worked over two miles on Salisbury Plain before representatives of the Navy and Army, and it is interesting to note that in these early trials he was using reflectors. These were soon discarded as they could only be used with very short waves which were only suitable, with the knowledge then available, for signalling over very short distances. But Marconi never forgot his reflectors, and nearly thirty years later, when conditions had altered, he changed the whole outlook of wireless communication by the introduction of reflectors for his short-wave beam system of wireless telegraphy.

As a result of these experiments in England, the Italian Government became interested, and invited Marconi to demonstrate his invention in Italy. This he did, in the summer of 1897, at distances up to ten miles, from the shore to a ship, and it was then that he noticed that the range of signalling could be increased by increasing the height of the aerial.

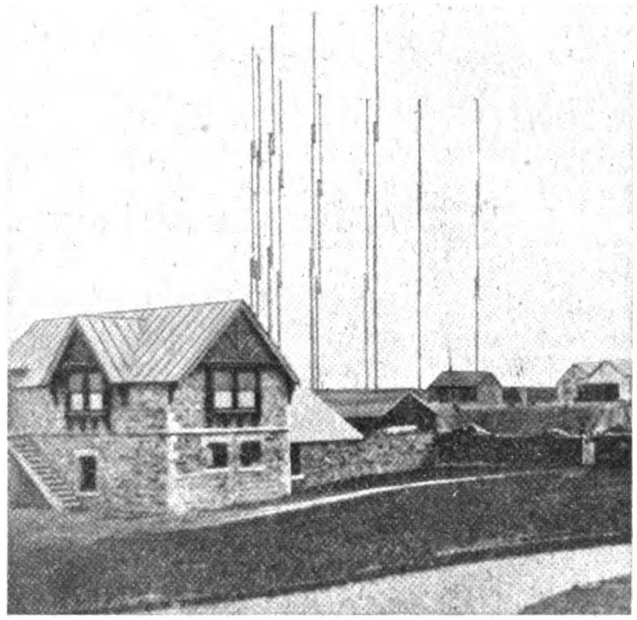
In the same year Professor Slaby of Germany, who had been an early experimenter with Hertzian waves and who had witnessed some of Marconi's tests in England, carried out experiments near Berlin, using 800-foot aerials held up by balloons. He signalled over a distance of 15 miles, which was greater than any range previously obtained.

The Advent of Commercial Wireless.

In July, 1897, the Wireless Telegraph and Signal Company, which later became Marconi's Wireless Telegraph Company, was formed in London, and wireless entered the commercial arena.

Marconi returned to England and continued his experiments. The East Goodwin Lightship was fitted, and in January 1899 it was damaged in a gale and reported the circumstances by wireless to a station at the South Foreland Lighthouse, twelve miles away. This was the first time that wireless was used in connection with the safety of life at sea. The first paid wireless message was sent on behalf of Lord Kelvin on June 3rd, 1898, from Marconi's station at Alum Bay, in the Isle of Wight, to his station at Bournemouth on the mainland.

On March 27th 1899 the Channel was bridged, signals being passed between the South Foreland Lighthouse and Wimereux, near Boulogne.



Poldhu wireless station at the time the first signals were received in Newfoundland in December, 1901. This was after half of the circle of masts had been blown down in a gale, and a makeshift aerial had to be used.

It was then that John Ambrose Fleming, who was well aware of the difficulties to be overcome, had the vision to see further than difficulties, and was not afraid publicly to back the new invention for all he was

* Through the courtesy of the Marconi Co. we have received a copy of a letter written by Commander (now Sir Henry) Jackson to Marconi, dated September 12th, 1897, part of which reads as follows: "*Whatever happens you have a full year's start of all, and the knowledge you have gained in your experiments will not be so easily gained by others who did not think out the system, and will be less interested in it than you and perhaps myself.*"

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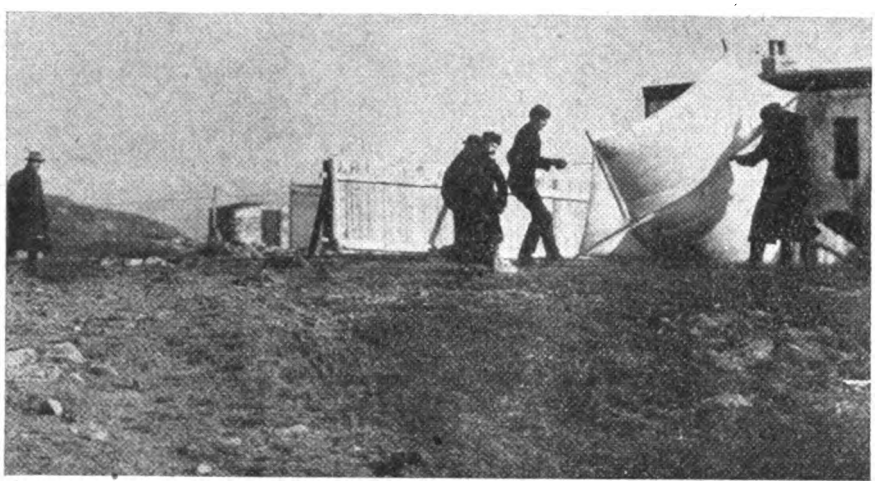
worth. The following is an extract of a letter which he wrote to the *Times* :—

> "Without denying that much remains yet to be attained, or that the same may be effected in other ways, it is impossible for anyone to witness the South Foreland and Boulogne experiments without coming to the conclusion that neither captious criticism nor official lethargy should stand in the way of additional opportunities being afforded for a further extension of practical experiments."

Thirty years later Sir Ambrose Fleming, as he is now known, became President of the Television Society. He could hardly give television a better public backing than that. Again the veteran scientist was not afraid publicly to back a new invention which was shrouded in an atmosphere of "captious criticism."* His courage has not aged.



Flying the kite which carried the aerial at Signal Hill, Newfoundland, in December, 1901. Marconi is on the extreme left of the picture, and Mr. Paget and Mr. Kemp, his two assistants on this occasion, are in the centre and extreme right respectively. This kite carried the aerial with which the first transatlantic wireless signals were received from Poldhu, Cornwall, on December 12th, 1901.

We have seen that the first wireless patent was applied for in 1896 by Marconi, and this was followed in May 1897 by Lodge's patent for tuning the transmitter and receiver. This latter was the fundamental tuning patent, and was upheld as such time after time in the law courts. It was eventually acquired by the Marconi Company in 1911. On April 26th 1900 Marconi filed the most famous of all wireless patents, British Patent No. 7777, universally known as the "Four Sevens Patent," which introduced the idea of having at both the transmitter and the receiver a closed tuned circuit coupled to an open aerial circuit similarly tuned. The arrangement was also patented in the United States, and for many years, for all practical purposes, gave the Marconi Company a monopoly of a tuned wireless system both in this country and in America.

Across the Atlantic.

Marconi, having bridged the Channel, set himself the task of bridging the Atlantic. Little was then known about how wireless waves travelled through space, and even yet much remains to be known. It was generally held, even amongst many of the most eminent physicists, that transatlantic signalling was an impossibility, principally owing to the curvature of the earth. Marconi, like Baird to-day, was not in the least perturbed by the opinions of the most eminent physicists, or anyone else. His idea was to make the attempt; if it was an impossibility he would fail; if he succeeded he knew that he could leave it to the same eminent physicists to explain how it had been done.

In 1901 he built the world's first high-power station at Poldhu, in Cornwall. The aerial, in the form of an inverted pyramid, was suspended from four wooden towers. The first masts to be erected were 200 ft. high. They were wrecked by a gale, and 170 ft. masts were erected in their place. The power was obtained from an alternator driven by a 25-h.p. oil engine. Transformers were used for obtaining the voltage required to charge the condensers, which consisted of glass plates coated with tin foil immersed in oil. Marconi then went across to Newfoundland where, after many troubles, he managed to raise an aerial to a height of 400 feet by means of kites, and he connected the aerial through tuning circuits to a Mercury Coherer, as used in the Italian Navy. On Dec. 12th, 1901, Marconi received from Poldhu a series of the letter "S," the first signals ever sent by wireless across the Atlantic, a distance of 1,800 miles.

In the following month he received signals from Poldhu in the liner *Philadelphia* at 2,099 miles, and it was then that he noticed the daylight effect, that is, the decrease in the strength of signals in daylight, and the fact that this weakening effect was counteracted to some extent by increasing the length of the waves.

The Amateurs Step in.

Professional experimenters seized on this fact, and the longer the ranges to be traversed the longer the waves they used. It became a sort of obsession, so much so that when amateur experimenters began to take up the subject seriously they found that no Government would allow them to experiment on any of these long waves which were considered sacrosanct to commercial communication. The amateurs were allowed to "play about" on the short waves, as they could not do much harm there. And they did not do much harm. On the contrary, they showed, in 1921, that short waves were quite suitable for long-range communication. The whole outlook of wireless was completely changed.

The wireless amateurs were the pioneers in this great advance, and it is an inspiring precedent for amateur workers at television.

(The author is indebted to Marconi's Wireless Telegraph Co., Ltd., for the illustrations in this article.)

* It is interesting to note that in the pages of this magazine last year Sir Ambrose Fleming has written of television that it is "*A quite genuine and veritable scientific invention . . . as important as telephony or broadcasting. . . .*

"*What has been done may not be altogether perfect, and there is undoubtedly much scope for further development, but the achievements to date have a scientific basis. . . .*"

"*. . . That recognisable images of moving and living objects such as human faces have been transmitted even to large distances by wire and by wireless, by Mr. Baird's methods admits of no manner of doubt. Those who deny it have simply not seen it. There are sufficient credible witnesses of it to place it quite beyond the region of dispute.*"

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Some Theories of Photo-Electric Action

By H. WOLFSON

IN our previous study of the photo-electric effect we have been content merely to attribute the action to photo-electrons, without considering too closely the nature and properties of these electrons. The questions which we must now ask ourselves cannot be answered in a few random words or sentences, for the subject is essentially one of great difficulty; in fact it is only within the last few years that any real progress has been made in elucidating the problems.

We should like to know whether the photo-electrons are to be regarded as a class unto themselves, or if they can be identified with any of the three existing classes of electrons, namely:—

(1) Valency electrons. These are the electrons in the outer ring of the system composing the atom, eight being the maximum number which is found in any atom.

(2) The free electrons, from which arises the conductivity of metals.

(3) The emission electrons, which are responsible for the absorption of light by a substance, and also emit radiation at higher temperatures. The Zeeman effect can also be attributed to these electrons.

There seems to be some doubt as to the separate existence of even these three classes, some attempts having been made to fuse classes (1) and (3). In an earlier article,* the selective and normal photo-electric effects were discussed in some detail, and one must consider the possibility that the electrons which give rise to the one type of effect may not be concerned in the other.

The field of photo-electricity, like so many others, gives rise to much speculative reasoning, which alone is unlikely to prove of much permanent value, unless combined with serious experimental work. Pohl and Pringsheim, as a result of careful work, suggest that the electrons which are concerned in the selective effect are closely connected with the chemically binding, or valency, electrons. Stark also believes the valency electrons are the same as the photo-electrons. We have seen already that Lenard, in his theory of phosphorescence, draws a distinction between photo-electrons and emission electrons, by supposing that the excitation by light of a phosphorescent substance causes the separation of the photo-electrons, which on their return to the atom set in vibration the emission electrons, which, as their name implies, give rise to the luminescent light.

In his previous study of the photo-electric effect the writer of this article has been content to attribute the action to photo-electrons without considering too closely the nature of these electrons. It is only of recent years that efforts have been made to probe further into the question, with a view to determining whether photoelectrons should be regarded as a class unto themselves, or whether they can be identified with any of the three existing classes of electrons, viz.: Valency electrons, free electrons, and emission electrons.

It has also been found that when a metal forms a compound more energy is required to separate the valency electron than previously. This means that light of a higher frequency (shorter wave-length) is required to remove the valency electron, since the greater energy, $h\nu$, can only be obtained by increasing the frequency ν.

On the basis of the Lewis-Langmuir theory of the atom, in which a geometrical arrangement of electrons in atoms is suggested, one assumes that in the inert gases the electrons are placed so as to give a balanced system, and the attempts of all elements to imitate this stable arrangement of the inert gas type have been regarded as the clue to chemical combination. In the electro-positive elements there are one or more electrons in the outer shell of the atom which can be displaced with the expenditure of but a small amount of energy. Ordinary light, of the frequency scale of the ordinary spectrum, possesses enough energy to bring about this displacement or separation of the electron from the atom.

According to the earlier theories of Bohr, often termed the Rutherford-Bohr theory, the atom is regarded as a miniature solar system, though in his later theory Bohr postulates the idea of energy levels, or stationary states. He still distinguishes between the properties of the central and peripheral parts of an atom, for while X-ray spectra have their origin in the innermost part of the atom, the ordinary spectra, and the electrons liberated by light, which are responsible for the chemical behaviour of the atom, are attributed to the peripheral electrons.

We must next enquire: "How do the electrons acquire sufficient energy to escape from the surface of the photo-electric substance?"

First we might imagine that under the influence of light the atoms of the substance become unstable, and, by a process analogous to an explosion, project electrons from themselves. The velocity of projection acquired would be of the same order as that possessed by the electron within the atom. This theory was probably suggested by a consideration of the theory of radio-activity, and we should have to assume that irradiation of a substance by light conferred on it some form of radio-active property. If this were so the energy would be obtained from

* TELEVISION, Sept., 1928, p.13.

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the internal energy of the atomic system, and would be inevitably accompanied by some form of atomic radio-active disintegration. This is contrary to the facts of the case, and furthermore we know definitely that radio-active disintegration is totally unaffected by any external agency whatever. Then, too, assumptions such as these would seem to suggest a constant energy or initial velocity for the photo-electrons, unless we were to complicate the issue by fresh assumptions, designed to explain the well-known fact that the energy of photo-electrons varies with the frequency of the exciting light. It seems, therefore, as if we must regard this hypothesis as untenable in the light of experiment.

The second view regards the electron as liberated in consequence of the velocity imparted to it by the passage of a half-wave of light—i.e., the kinetic energy of the electron is derived from the energy of the incident light. We know that the initial velocity in the case of aluminium is about 8×10^7cm. per sec., which is too large to have come from a half-wavelength vibration of the usual intensity. Further than this, we have already seen* that the velocity of emission of the photo-electrons does not depend on the intensity of the illumination from a given source. Other objections could also be given, but space does not permit of this.

Thirdly, we may suppose that the electrons, which have, of course, free periods of vibration, are set in vibration by resonance, when illuminated by light waves of the same period as their own. They thus acquire kinetic energy from the resonance vibration which is sufficient to set them free from the atom. Here again we are confronted with the difficulty that in order that the electron shall leave the atom with a finite velocity, it must acquire more energy than it requires to merely set it free. This would be derived directly from the light, and we should expect that the initial velocity would increase with the intensity of the light.

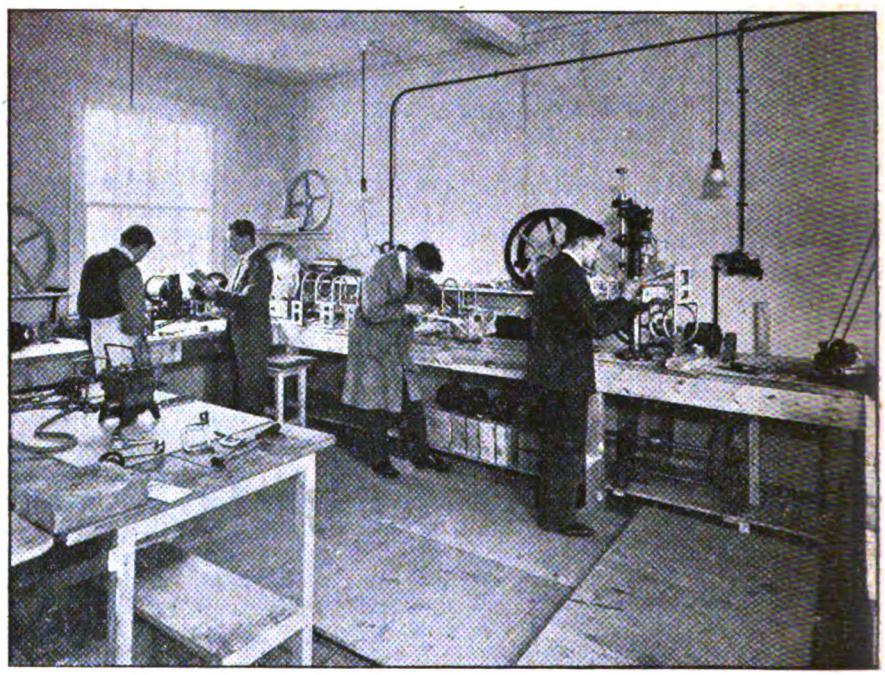
Lenard has got over this fundamental objection by assuming that within the atom the electron performs a complicated motion which imparts to it sufficient kinetic energy to give to it a velocity when liberated from the body, and thus it would seem that the resonance vibrations merely act as electron liberators. Lindemann has further investigated this theory, and derived a formula, giving the relation between the initial electronic velocity and the frequency of the light, but the theoretical reasoning leaves much to be desired, so that it seems preferable not to attach too much importance to it.

The application of the quantum theory to photo-electricity has resulted, as in so many other branches of science, in the elucidation of many difficult points. The idea of this theory is that energy is not transmitted and received as a whole, but in the form of a number of full quanta, of definite magnitude. The size of a quantum of radiant energy depends on the frequency of the radiation being defined, as we have already seen, as the product h, where "h" is Planck's constant of value $6{\cdot}55 \times 10^{-27}$ erg. sec. We should be familiar also with the idea of "concentrated quanta," by which we mean that not only is the energy of a quantum a small definite amount, but it remains confined to a very small space.

If a sensitive plate is placed at a small distance from a constant source of light, and the velocity and number of the emitted electrons is determined, and the plate is then removed to a distance away ten times as great as before, so that the intensity of light energy is diminished one hundred times, then it will be found that the *number* of electrons becomes one hundred times less, but their *velocity* remains unaltered.

This would be so if the number of concentrated quanta were cut down by 100, while the "virulence" remains unaltered, so that each concentrated quantum can do at a great distance exactly the same as it did at the smaller distance. If we do not accept this view, then the energy would spread out, and at a certain distance would have become too feeble to liberate an electron. On the other hand these concentrated quanta or limited disturbances of equilibrium, cannot be reconciled with other theoretical considerations, such as are contained in Maxwell's undulatory theory of the electro-magnetic field.

Einstein has extended Planck's hypothesis by proving that monochromatic radiation which obeys Wien's radiation law behaves as if it consisted of light units of magnitude $h\nu$. Each unit of energy can only be emitted or absorbed as a whole, it moves outwards from the source as such, and is incapable of subdividing. The photo-electric emission is explained by supposing that the kinetic energy already possessed by the electron within the atom is augmented by energy derived from a light quantum, from which it is easy to trace the proportionality between the



Assembling and testing television receivers at the Baird laboratories.

* TELEVISION, NOV., 1928, p.24.

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number of electrons emitted and the radiation intensity, and also the independence of the velocity of the

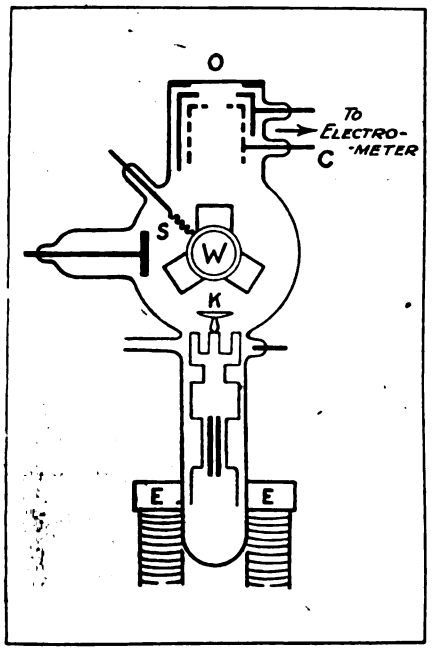

Fig. 1.
Millikan's apparatus for proving Einstein's mathematical prediction. E=Electromagnet.

electron on the intensity of the exciting light.

Although only a definite fraction of the energy of a light quantum is transferred to the electron, it is far simpler to assume with Einstein that the whole energy is given to a single electron. Then the energy with which the electron leaves the body is the kinetic energy $\frac{1}{2}mv^2$. This is equal to $h\nu - P$, and is Einstein's photo-electric equation. Stated more fully, if V is that positive potential which just prevents the electron from leaving the body, we get—

$$Ve = \tfrac{1}{2}mv^2 = h\nu - P.$$

The value of P depends on the threshold frequency of the particular photo-electric substance under consideration, and is equal to $h\nu_0$, where ν_0 is this threshold frequency, by which we mean the particular frequency below which no radiation will ever occur.

This bold mathematical prediction of Einstein was put forward as early as 1905, and has since been subjected to rigorous proof by the beautiful experiments of Millikan and his co-workers. The apparatus employed was rightly described by Millikan as "a machine-shop in vacuo." It is illustrated in Fig. 1. W is a wheel carrying cast cylinders of the alkali metals, K is a rotating knife to cut shavings from the metal surfaces in order to expose a fresh and bright new surface.

The metal under examination is brought opposite the incident light from O by turning the wheel W electro-magnetically. A positive potential is applied to the metal surface just strong enough to prevent electrons from reaching the gauze cylinder C, which is used in conjunction with a quadrant electrometer. The plate S is used as a test plate for measuring the E.M.F. between the new surface and the standard plate. The source of light was a quartz mercury vapour lamp, and stray light of short wave-length was carefully excluded by means of filters.

Four important points were proved by these experiments.

(1) There exists a definite, determinable maximum energy of emission of electrons under the influence of light of a definite frequency.

(2) There is a linear relationship between photo-potentials and the frequency of the exciting light. A graph which could be drawn shows that six points observed fall exactly on one straight line (Fig. 2).

(3) The agreement of the potential-frequency line intercept with the long wave-length limit, the former having been displaced by an amount corresponding to the contact E.M.F. The dotted line in Fig. 2 shows this displaced position, the contact E.M.F. being 2·51 volts. The intercept is at $V_0 = 43{\cdot}9 \times 10^{13}$, corresponding to $\lambda_0 = 6800$ Å. This diagram is taken from Millikan's own book, "The Electron."

(4) The slope of the line $dV/d\nu$, where V is the potential difference, is theoretically equal to h/e Planck's constant/electronic charge, and knowing e very exactly, this gives us the best way of evaluating Planck's constant h. The value obtained is $6{\cdot}57 \times 10^{-27}$ erg. sec.

Millikan's experiments have performed a double purpose. Not only do they completely verify Einstein's theory, but they also give this extremely accurate value for h. Kirchner thinks it possible to deduce the various fundamental photo-electric constants from a consideration of the structure of the atom. He assumes that at the surface of a metal there are atoms which are electrically free, these being atoms of metal vapour, and he deduces the desired constants from terms for the energy which have been derived from spectroscopic measurements. He claims to be able to find suitable values for the threshold frequency, maximum emission energy, and the position of the region of maximum sensitiveness. The conclusion has also been reached that two electrons are never liberated from the same molecule at the same time. This

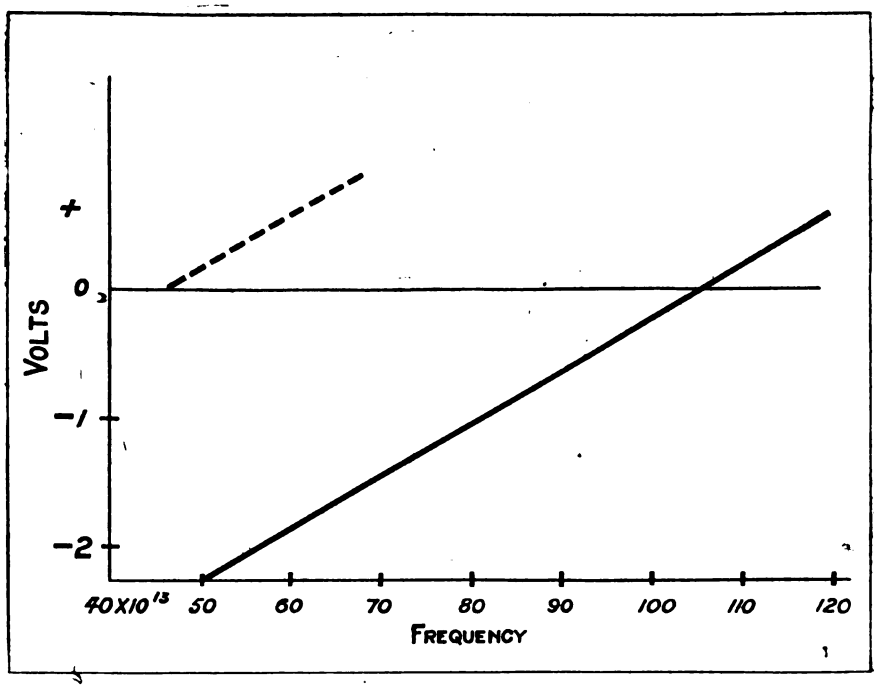

Fig. 2.
Millikan's results shown graphically.

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result has been amply confirmed by a number of workers.

Richardson has discussed photo-electric emission on the view that the metals contain a large number of free electrons, which are retained within the metal by the action of forces near the boundary, giving rise to work functions characteristic of each metal. The electrons are dynamically equivalent to the molecules of a gas, and this leads to an elaborate mathematical treatment of the problem. The main point of interest derived from the mathematical maze is that the maximum emission should occur when $\nu=\frac{3}{2}\nu_0$. This gives us a means either of finding the threshold frequency when given the frequency of maximum sensitiveness, or alternatively, of finding the maximum emission frequency from a knowledge of the threshold frequency, obtained from other experiments.

The maximum and the mean energies of photo-electrons can be determined from the velocity distribution curves which we discussed last month. Compton and Richardson found that their results could be expressed as maximum energy $T_m=k_m(\nu-\nu_0)$, and mean energy $T_r=k_r(\nu-\nu_0)$. The table in Fig. 3 gives some idea of the numerical values. The values obtained from considerations of mean energy agree with those from maximum energy very closely except in the case of aluminium.

The question of the number of electrons emitted in unit time is also discussed by these workers (Compton and Richardson). The suggested solution of one of the integrals in their paper is capable of predicting both the value of the maximum emission frequency and the threshold frequency, but experiments seem to point to the existence of another term in the solution of the equation, since the curve for electrons emitted wave-length gave two maxima. This result has been questioned by Souder. One term may stand for the selective and the other for the normal effect. This is all speculation, since repeated attempts have failed to discover such a solution to the equations.

I have already mentioned in a previous article* that the phenomena of photo-electric emission, contact potential, and thermionic emission are closely connected with one another. That they are due to chemical action is a view which, in the light of our present knowledge, cannot be accepted. The primary factor in each case is the amount of work which must be performed in order to liberate an electron from the surface of the substance under examination.

Following on his photo-electric equation of 1905 Einstein suggested in 1906 that there was a relation between the Volta contact potential difference between two metals, and the smallest frequencies which are photo-active. Compton and Richardson state that the value of P in Einstein's equation for two different metals A and B were connected with the corresponding contact potentials by the equation.

$$P_A - P_B = e(V_A - V_B).$$

This equation was confirmed by direct measurement of the emission energy of thermionic electrons and by determinations of threshold frequencies from the relation

$$P_A=h\nu_A \text{ and } P_B=h\nu_B$$

from which one obtains Einstein's result—

$$V_A - V_B = \frac{h}{e}(\nu_A - \nu_B).$$

Millikan is strongly in favour of recognising the connection between contact potential and the constant term in Einstein's equation. If an electron be ejected from a metal A through the agency of light of frequency into a Faraday cylinder made of a more electro-negative metal, then if the electron be just brought to rest as it reaches the cylinder wall the ejection energy is equal to the positive potential V_A applied to the cylinder plus the contactp ot ential, K_A

$$\tfrac{1}{2}mv^2 = e(V_A + K_A).$$

According to Einstein the energy of ejection of the electron is

$h\nu-P_A$, or $h\nu-h\nu_A$, where ν_A is the threshold frequency of the metal A.

Equating these two, and repeating a similar process for a metal B, we get by subtraction that

$$(V_A - V_B)e + (K_A - K_B)e = (P_B - P_A)$$

$K_A - K_B$ is, of course, the contact E.M.F. between the two metals.

In later work Millikan splits P into two parts, P_1 and P_2, being respectively the work necessary to detach the electron from its atom, and that work necessary to push the electron thus freed, through the surface of the metal. This gives two sets of terms at the end of the last equation in place of one. Further, since $(P_{2B} - P_{2A})/e$ is the contact E.M.F. between A and B, i.e., it is $K_A - K_B$, we see that

$$(V_A - V_B)e = P_{1B} - P_{1A}.$$

Working with sodium, potassium and lithium the stopping potentials are found to be the same. Thus,

$$P_{1B} - P_{1A} = 0.$$

This means of necessity that either the work of detaching an electron is the same for all metals, or else that the electron loses no energy in getting through the metal surface. Millikan dismisses the first, since it is not in agreement with our ideas of ionisation potentials, and the second implies one or other of two things:—

(*a*) The incident light can take hold of an electron and impart to it an energy $h\nu$.

(*b*) The incident light energy is not absorbed in quanta. This view is hardly acceptable.

The threshold frequency was thought at one time to have only one value, but in 1925 it was shown that for sodium and potassium, at any rate, there are multiple thresholds.

Metal.	Value from max. energy.			Value from min. energy.		
	$\nu_0 \times 10^{-13}$.	λ_0.	K_m	$\nu_0 \times 10^{-13}$.	λ_0.	K_r.
Na	51·5	583	5·2	52	577	2·6
Al	63·0	477	4·3	73	411	2·6
Mg	78·5	382	5·2	80	375	2·55
Zn	80·0	376	5·1	84	357	2·8
Sn	83·0	362	4·9	89	337	2·75
Bi	91·0	330	3·55	89	337	1·9
Cu	100·0	300	3·80	97	309	1·65
Pt	104·0	288	5·85	103	291	2·8

Fig. 3.

* TELEVISION, June, 1929, p. 174.

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The Story of Chemistry

Part XI

Counting the Elements

By W. F. F. SHEARCROFT, B.Sc., A.I.C.
Fellow of the Television Society.

IN an earlier article it was stated that chemists are of the opinion that there are only 92 elementary substances in the universe, and we may round off this series of articles with an attempt to explain the evidence on which this is based.

The electron is familiar to all of us. It streams away from the hot filament in our thermionic valves. Quite what it is, we do not know, and it bothers the scientists as much as it seems to upset Mr. Swanne. It has been said that the best way of dealing with it is to think of it as a particle for three days of the week, and as a wave for the rest. Although doubtful as to its exact nature, we know much about it what will do.

Enormous Velocities.

It is possible to produce streams of electrons moving at enormous velocities. When such a stream is allowed to impinge on any form of matter certain phenomena occur, which we call the production of X-rays. These rays are now so familiar that little need be said about them. They are short rays, similar in all respects to light waves, which again are but one group of the electromagnetic waves which give us the waves of the wireless, the infra red, luminous, ultra violet and other rays. Owing to their extreme shortness they are able to penetrate ordinary matter to a much greater extent than light waves, and their use in medical practice for making photographs of internal parts of the body is well known.

The group of radiations which we know as light vary as to their colour, a variation which the physicist relates to wave-length. The longer rays give us the sensation of redness, the shortest ones give us our violet sensation. They differ not alone in the different sensations they give us, but in other respects as well. Thus red light, that is light of the longest wave-length, has very little action on the chemicals on a photographic plate, while the violet rays have a very marked effect.

The group of rays which we class as X-rays also differs in wave-length. Some are longer than others. The shorter X-rays are called *hard*, while the longer ones are described as *soft*. The harder the ray the greater its penetrative power as regards matter.

X-rays are produced in an X-ray tube in which a powerful stream of electrons is made to impinge on a plate of some material. The nature of the material composing this plate has a marked effect on the nature of the X-rays produced.

Rearrangement and Combination.

Chemical action we have supposed concerns mainly the outer sheath of electrons surrounding the nucleus of the atom. Rearrangements and combination between the outer sheaths of atoms affords one explanation of chemical union. Now, it is reasonable to suppose that when matter is bombarded by tiny electrons that these may get down beneath this outer sheath, and that the phenomena of X-rays is, therefore, a manifestation originating deeper within the atoms than chemical manifestations. So we can understand that, shortly after the enunciation of the nucleus atom theory, an intensive enquiry was undertaken as to the nature of the X-rays emitted by the elements, in the hope of discovering something of the internal nature of the atom.

Now, when X-rays are allowed to bombard specimens of the elements they initiate the production of other X-rays from the specimen, X-rays which we might call secondary. Barkla in 1905 showed that these secondary X-rays were characteristic of the element. X-rays are characterised by their wave-length, and to somewhat simplify the complication, it was found that each element emitted rays of a characteristic wave length.

Coefficient of Absorption.

Barkla measured the coefficient of absorption of the rays emitted for aluminium plates—for practical purposes we may look upon this as a measurement of the thickness of aluminium required to completely stop the rays. (A sufficient thickness of glass is opaque to light, and it is quite dark a short distance below the surface of the sea.) He came to the conclusion that the hardness of the rays increased with the atomic weight of the element from which the secondary rays proceeded. He also discovered that the majority of the elements appeared to possess two absorption coefficients, which differed widely in value. They were named the K- and the L-radiations, the former being the harder.

Later work considerably increased the technical side of this investigation By means of what is known as the "revolving crystal" method, it became possible to split up these radiations much in the same way as light is split up in the spectrum.

In 1913 that brilliant experimenter Moseley succeeded in resolving the K- and L-radiations into distinct sharp lines. Later, two further series of radiations were found called the M- and N-radiations. Now it was possible to make precise measurements and study the results

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It was found that the "spectrum" of these radiations was as characteristic of the element producing them, as is the light spectrum.

The result of this work was striking in the extreme. Considering one particular line in these spectra it was found that the elements could be arranged in a series, numbered consecutively, and, in this arrangement the square root of the frequency of the line increased linearly with the number of the elements. Put as simply as possible this means that to every element a *whole number* could be assigned. Starting with hydrogen as 1, we get a series of elements ending at 92, and for each of the intervening numbers we can postulate the existence of an element, and the absence of any intermediate ones with fractional values.

This number assigned to each element is known as the Atomic Number of the element, and the list obtained in this way agrees with the order of the elements in the Periodic Table, an order based on chemical considerations of a vastly different nature. The Periodic Table in which the elements are arranged in order of their chemical nature was supposed to illustrate the Periodic Law, which stated that the properties of the element were a function of the atomic weight, and thus the elements should appear in it in the order of their atomic weights. This, however, was not the case, there being notable exceptions in which chemical considerations outweighed the law. The elements in order of their atomic numbers are in that order which chemical considerations had placed them.

Thus, we now suppose that, starting with hydrogen and ending with uranium, we have 92 possible elements. Nothing is said as to the possibility of others beyond these limits, but we know that the heaviest elements are unstable, and spontaneously split up during radioactive changes, and we do not imagine that we are likely to discover further elements beyond uranium.

In 1803 Dalton proposed the first really complete form of the atomic theory, and for a century or more chemistry centred round the indistructible atom. It seemed that the science had almost reached its limit, and nothing remained to be done beyond further refinements of determinations. Then came the discovery of radioactivity, and the upheavals in the scientific world of the present century.

In these upheavals the chemist found the very foundations of his science in a state of chaos, and he was forced to review his position and, in doing so, gather a new view of the fundamental aspects of chemistry. Advances were rapid, and what was new was speedily incorporated into the structure of chemistry.

To-day it almost seems as if history might repeat itself. The newer model of the atom has been shown to give a truer and more complete explanation of the phenomena of chemistry. We have set a limit to the discovery of elements, a limit almost reached, and we seem to have reached a state when once again progress is waiting for some new discovery. There are not wanting signs that the future will provide it, and once again we may have to take up our foundation and lay it on a new plan, which we may feel certain will make it more sound for the extensions of chemical knowledge which will be built upon it.

A Novel Broadcast.

An American parachute instructor equipped for tests of a radio broadcast from a falling parachute. A "chin strap" microphone is fastened to his face, while around his waist is attached what is believed to be the smallest transmitter ever made. It was designed by engineers of the National Broadcasting Company. If tests are successful this man will broadcast the sensations of a parachute jumper in the midst of a drop.

The transmitter, having a range of approximately ten miles, according to tests already made from an airplane, weighs only 24 lb. with the microphone included. The case is made of light, strong wood, 14 ins. wide, 4 ins. deep, and 11 ins. high. Besides four batteries, the equipment consists of a modulating and oscillating circuit. A switch enables the transmitter to be turned on or off at the will of the operator.

At this stage, however, we propose to leave things, not that the "Story of Chemistry" has been completely told, or even adquately dealt with. We set out to place before the enthusiasts of a new science such an outline as would allow them to appreciate the chemical side of their activities. We hope that in so doing we have aroused interest sufficiently intense to encourage the further pursuit of the subject.

Chemistry is an intricate subject embracing a mass of technical facts, a highly technical method of experimentation, and a theoretical basis which has an intrinsic interest of very high merit. For whichever of these it is valued it will repay study, and it remains but to point the way along which that study is best begun.

On the experimental side of chemistry much may be done by the amateur with simple apparatus. Naturally with moderate equipment one cannot expect to rival the university laboratories for accuracy of determinations, but the foundations of the science were laid by men who were denied all these luxuries and whose apparatus could be almost duplicated from the back-kitchen supplies of domestic implements.

If practical applications are not possible or desired, then much may be done by the careful study of text-books, of which there are many hundreds on the market. A straightforward text-book should certainly be the starting point. The author's *Chemistry* (Bell), although written for the purpose of examinations, is a useful elementary presentation. It will lead naturally to larger texts, such as Martin Lowry's *Inorganic Chemistry* (Macmillan), and that delightful book by the same author, *Historical Introduction to Chemistry*. It is hardly necessary to go further than these suggestions here, for those who pursue them will by then be in a position to judge for themselves the lines along which they would then desire to extend their knowledge.

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THE SPOTLIGHT PRINCIPLE IN TELEVISION

Part II

By NORMAN J. NICOLSON

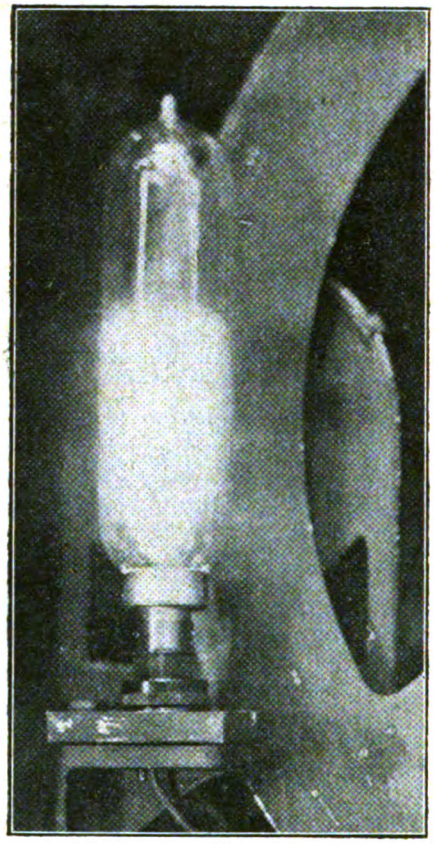
Continuing the interesting series of articles on the above subject which he commenced in our June issue, the writer gives below some further particulars concerning the spotlight principle, together with some valuable observations on the vital question of synchronism.

IN Part I. of this subject the writer endeavoured to explain, as lucidly as possible, details of how the spotlight functioned at the transmitting end, leading up to the point where the image, having been converted into electrical impulses, was consequently available for modulating the carrier-wave of any suitable broadcast transmitter. In this issue we propose to discuss the reception by wireless of these trains of impulses and their reconversion, by means of a television receiver, back again into the likeness.

First of all, in connection with the transmission of television it must be admitted that a wireless transmitter primarily designed for handling broadcast telephony only may not be altogether suitable for television purposes without certain modifications. These principally concern the values of its circuit components, made necessary to enable the plant to cope adequately with the higher frequency band entailed.

Frequency Bands.

Whether this band will exceed 10 kc. or not, with due regard to the international agreement restricting broadcast transmitters to sidebands below 10 kc., we must remember that this limitation was formulated at a time when broadcast television was not the practicable proposition that it is to-day. But should any successful system, such as Baird's, necessitate a somewhat broader band for its transmissions, the writer shares the opinion of many others that television will be considered to be of sufficient international importance to warrant special legislation on this issue. One possible solution to the problem is the allocation to television of short wave-lengths which, naturally, in view of their high fundamental frequencies, permit of much greater scope in respect of sideband interference.



Behind the Scenes.

Literally behind the scenes is the neon lamp, shown above, glowing in its normal position behind the scanning disc of a Baird "Televisor." Immediately behind the disc can be seen one of the magnifying lenses through which the image is viewed. The above is a back view of the instrument, the front of which is familiar to our readers.

Alternatively it is surely a worthwhile project for wireless interests as a whole to endeavour to hasten the new era of prosperity television is bringing towards them, by directing the resources of their research laboratories upon the discovery of a new and more economical method of modulation, as outlined by the Editor in the issue of TELEVISION for February, 1929.

Similarly, wireless receivers in order to deal efficiently with television broadcasts and their sidebands will have to be so constructed that their tuning is as broad as possible compatible with selectivity. It follows, therefore, that an integral part of the impetus which this new science will impart to the wireless industry is bound up in the technique of suitable receiver design.

Sensitivity of the Eye.

It is a matter for argument whether the eye will prove to be more critical than the ear in regard to wireless reception. Even nowadays, when the quality of broadcast telephony is generally understood to be of a very high order, we have no doubt that were receivers throughout the country tested on an oscilloscope for frequency response, the percentage delivering anything approaching a straight line characteristic over the entire musical scale would be found to be grievously small.

The inference is that most people listen to and enjoy programmes imperfectly reproduced without realising that any imperfection is present. It is well, therefore, not to lose sight of this fact in considering the difficulties attendant upon receiving television perfectly. Purposely evading

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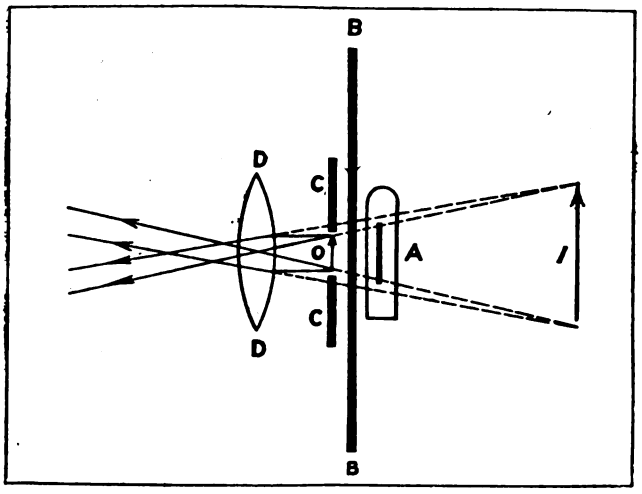

LAYOUT OF TELEVISION RECEIVER.

Fig. 1.

When a light source considerably more powerful than the neon lamp is available the lens DD could be placed in such a position as to project an image on to a screen of increased size.

any possible controversy which might arise from attempting to suggest what we consider would be a suitable circuit to adopt (apart from mentioning that current practice favours R.C. coupling) we must, however, dwell a little on the output stage of such a receiver. This has to be of such an order that the neon lamp in the television receiver can function.

Neon Voltage Reduced.

Recent research has evolved a neon lamp which has a striking voltage of as low as 175 volts. Experiments with this have now reached such a degree of finality as to prove that it will operate satisfactorily off an ordinary output valve of the "super" variety possessing a grid swing of from 20 to 40 volts. Previously, with neons whose minimum striking voltage was considerably higher, it was necessary to use a valve with a grid swing in the neighbourhood of 60 volts. A receiver to operate this newer type of neon may be run off an eliminator just as readily as the average telephony receiver which is capable of operating a moving-coil loud-speaker.

Provided the neon is coupled up to the set by means of an auto-transformer or choke, the H.T. voltage for such a set need not exceed 200. The output impedance should not be more than 2000 ohms. The above data, we trust, will tend to correct a common impression that an abnormally high H.T. voltage will be required in television reception. The bias on the last valve is so arranged that the neon glows whether the receiver is tuned to the incoming signal or not. As soon as it is in tune the current passing through the lamp will vary proportionately to the value of the current impulses, a strong impulse heightening its brilliance and a weak impulse dimming it.

We arrive now at the layout of the "Televisor" itself, which is illustrated diagrammatically in Fig. 1. This consists of the neon lamp (A), mounted behind the revolving disc (B), a framing mask (C), and a magnifying lens (D) is situated a short distance in front of the disc.

Provided the essentials of converting the image into current at the transmitting station by spotlight have been understood it should now readily be grasped that at the receiving end, with a corresponding disc rotating before a neon lamp at identically the same speed, and aperture for aperture, as the scanning disc at the transmitter, the effect seen looking into the illuminated portion of the disc will be that the original spots and strips of the image scanned by the spotlight and picked up by the photo-electric cells will be visible and, of course, the rapidity of their reproduction causes them to appear as a continuous image.

Negative Images.

An important factor which arises here, and which will undoubtedly cause a certain amount of confusion at first, is that it is possible to obtain a negative effect in our picture as well as the result desired—i.e., a positive. In a negative the light values of the image are seen exactly the opposite

(*Continued on page* 303.)

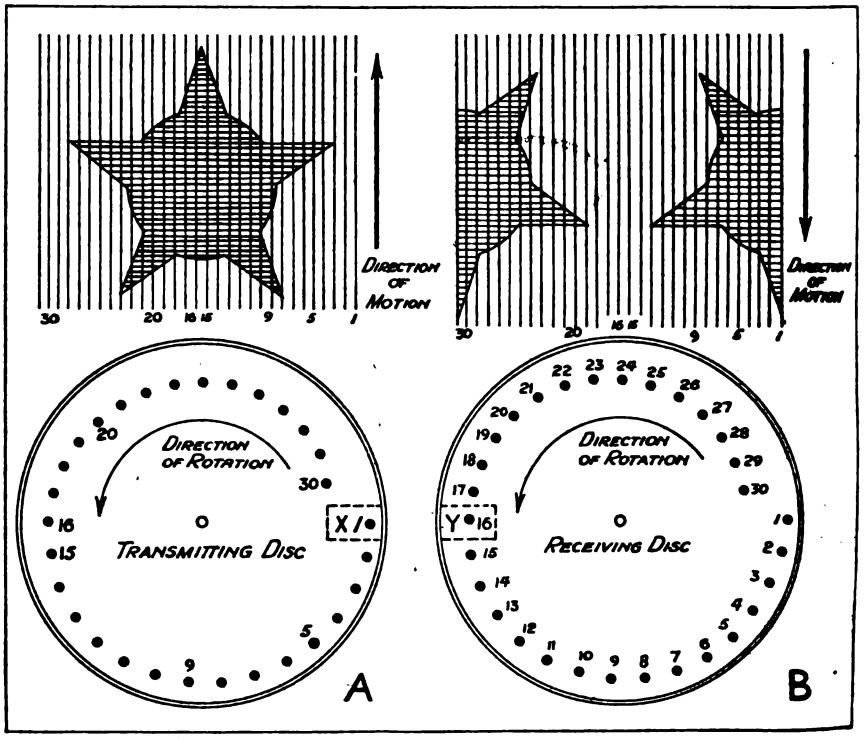

Fig. 2.

Here we have our two discs, transmitting (A) and receiving (B), drawn for comparison together with their respective signal strips, which are shown numerically, and the result which would be seen by placing the neon (Y) 180° out of its correct position, the synchronising being set for the latter. X represents the scanning portion of the transmitter. The image of the star appears split and inverted, and this may be followed out from the strips. Strip 1 created by aperture 1 in the transmitter passes no signal to the neon in the receiver. Now strip 16 of the receiving disc is passing the neon at this moment in the reverse direction, with the result that strip 16 has no signal and part of our picture is blank. Strip 5 of the transmitter encounters a piece of the star which is reproduced upside down by strip 20 receiver. Strip 15 receiver is modulated by strip 30 transmitter, and so on.

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Mains Brevities

By WILLIAM J. RICHARDSON

In recent issues we have devoted a considerable amount of space to the question of battery eliminators, and in our May issue we published an article which gave full constructional details of a complete mains unit suitable for an alternating current supply. In the following article our contributor deals with the question of operating wireless receivers and amplifiers from a direct current supply.

THE modern house provides a potential source of power for operating a wireless receiver which, in these days of high voltages and heavy plate current demands, we cannot afford to neglect. While no one can gainsay the fact that there are now on the market large H.T. and L.T. batteries which are capable of meeting current drain, often it becomes an expensive business. Furthermore, valves are now being developed to a high degree of perfection which may be worked direct from the house mains for rendering the filaments operative, and that is a great advantage.

With such a wide scope afforded it is advisable to study a few of the points which merit consideration in mains working and, first of all, it would seem appropriate to weigh up the advantages and disadvantages, and thus see if it is "worth while." Turning over all the advantages in my own mind it becomes obvious that the appeal to the individual will vary according to taste, and in regarding economy as the main advantage I am not being dictated to by any national characteristic, for I am not a Scotsman! Of course, the actual cost per annum will depend upon the supply company's charges for the district, but whatever this is the monetary total works out at a much smaller figure than that met by battery renewals and accumulator charges, while there is always in the background the memories of the journeys to and from the charging station which are saved.

Advantages and Disadvantages.

Mains units, once adjusted, need little or no further attention. They are simple to control, and above all, are convenient, with cleanliness and tidiness as noteworthy additional features. Furthermore, there is an ample margin of safety owing to the incorporation of fuses, and they are reliable provided good quality components are used, for it is seldom that the electricity supply fails, whereas batteries and accumulators have an unhappy knack of letting you down at the most inopportune moments.

To offset these gains we have the higher first cost, but this is soon counterbalanced by the almost complete absence of renewals and upkeep. Any inefficiency in the house wiring system will pass on that inefficiency and may give disappointing results; the receiving set wiring generally has to be altered somewhat unless a new one is being made, and finally there is the difficulty arising out of the lack of uniformity with the various supply systems throughout the country. Taken as a whole, however, it should be quite evident that mains working has advantages which easily outweigh the disadvantages.

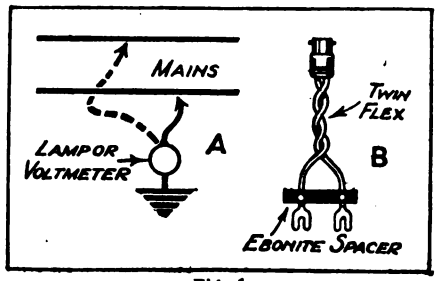

Fig. 1.
Testing to find the earthed main.

Use as an Aerial.

No doubt many have overlooked the fact that the electric light mains form quite a convenient aerial owing to the large network of conductors distributed throughout the house. But a word of warning on this point! Do not imagine that it only means connecting the wiring direct to the aerial and earth terminals on the set unless you are prepared to have the main switch open. Should this be inconvenient, just insert a reliable mica condenser in each lead before connection is made, and the set will be isolated effectively. The receiver tuning arrangements may require a slight modification, for it is better to regard the house wiring as a large untuned collection of the wireless signals and employ an aperiodic or, better still, a tight magnetic coupling for passing this energy on to the tuned circuits.

Ascertain which main is earthed—see Fig. 1A, no lamp ignition or zero voltmeter reading being obtained from the earthed main—and make up a small condenser test board for finding the best condenser combina-

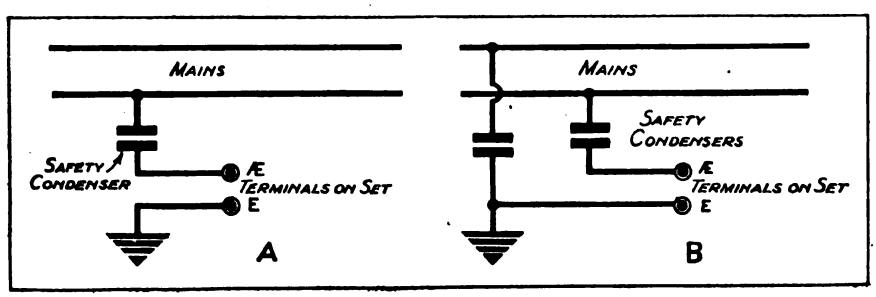

Fig. 2.
Using the mains as an aerial.

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tion to use. Employ a flexible lead terminating at one end with an adaptor for plugging in at the mains, and an ebonite spacer at the other end to keep the leads apart and prevent accidental short circuits, see Fig. 1B.

On tests which I have carried out it was found best to have a direct earth lead included, and with either of schemes Fig. 2 A and B, and tight

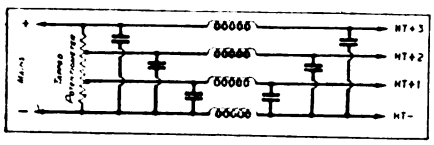

Fig. 3.
A smoothing circuit for D.C. mains.

magnetic coupling to the tuned grid coil, the capacity of the safety condensers could vary between the limits of ·0001 to ·002 mfd. with little reception difference, and practically no mains hum was audible. If the direct earth is omitted, a slight mains hum can generally be detected, while the safety condensers must then be of the order of ·002 mfd. The use of a mains aerial where such can be arranged is a great boon, especially in those situations where the erection of an efficient aerial, either indoor or outdoor, is out of the question. There is no worry about earthing switches and

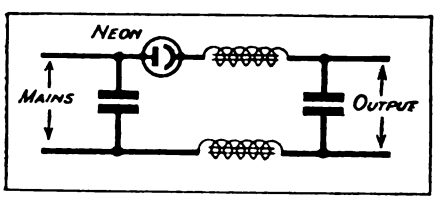

Fig. 4.
An alternative smoothing circuit.

lightning devices; just remove the plug adaptor from its accommodating socket and the set is isolated when not in use.

Smoothing D.C.

Where a D.C. supply is available of high enough voltage to meet H.T. requirements, it becomes necessary to include some form of smoothing device between the set and the supply point to reduce the unwanted mains ripple. Large iron cored chokes are recommended for each positive tapping lead—a potentiometer or lamp resistances of suitable value will give the voltage regulation desired—with a further choke in the negative lead and reservoir condensers between the extremities somewhat as indicated in Fig. 3. As to inductance values, these depend very largely upon the "quality" of the supply, but they should be rated at 50 henries (preferably larger) for the maximum current demand. The condensers must be of high grade and tested to twice working voltage, and they vary in size from 4 to 10 mfd.

The frequency of the ripple is not only governed by factors situated at the individual source of supply, but depends to a very great extent upon the type of power demand made in the locality. Thus, a unit may be wholly free from hum at its output terminals when installed at one place, but produces a definite hum when operating in a different area fed from the same supply. This is most marked where a large number of motors may be working, such as in an industrial quarter of a city, the frequency and magnitude of the fluctuations verying from time to time depending upon peak loads, etc. Transferring the scene of activities to the residential districts, where the mains are primarily used for lighting and heating, the units will be found silent in operation.

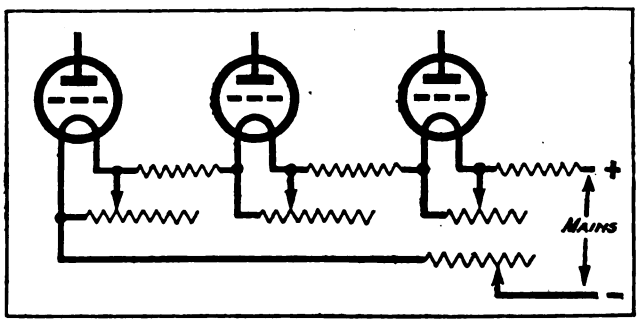

Fig. 5.
How valve filaments, connected in series, may be run off the mains.

A "District Factor."

The presence of this "district factor" must always be borne in mind, and adequate provision made for same in the smoothing arrangements, a double smoothing often proving a necessity. When only a limited output is desired, the voltage of the mains can be broken down, and smoothed with the scheme of Fig. 4, a neon lamp being used. If one of the familiar beehive pattern is employed it is generally advisable to remove the resistance included in the cap.

There is one important precaution which must not be lost sight of with all receivers connected across the mains for power supply and that is, the danger of a short. Invariably one side of the mains is earthed, and should this be the negative, little difference will arise, but if it is the positive, then the negative is 240 volts above or below earth potential. If H.T. be earthed direct at the receiver, a dead short will take place. This difficulty is overcome quite easily by including a 1 or 2 mfd. fixed condenser in the earth lead, that is, between the earth itself and the earth terminal on the set. The capacity isolation will in no way effect the working of the set providing the condenser incorporated is of good quality, and has a low equivalent high frequency resistance, since it is in the aerial circuit. Even if the negative main is earthed at the power station, a test generally shows the main to be a few volts above or

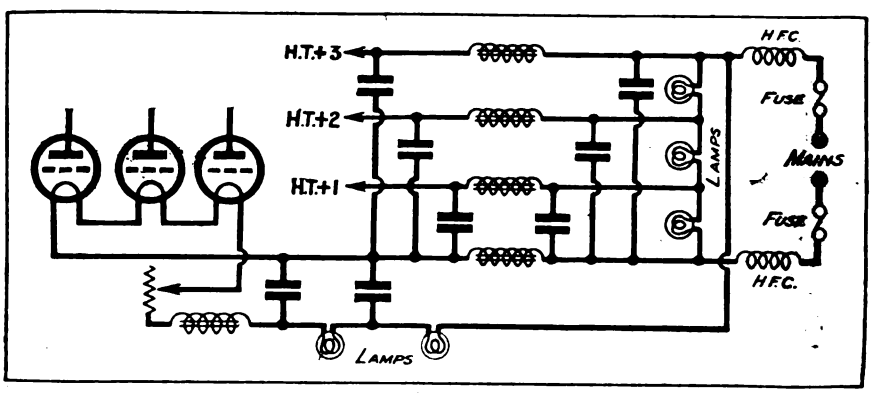

Fig. 6.
A complete circuit, showing how both L.T. and H.T. requirements can be met from the D.C. mains.

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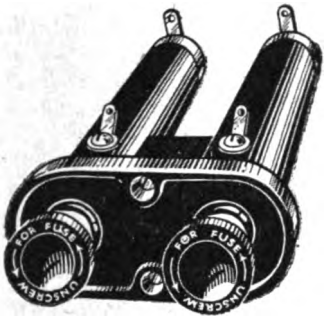
below earth potential, so the inclusion of this condenser in every case will prevent current leakage.

If it is desired to run the valve filaments from the D.C. mains, the problem becomes a trifle more complicated. Obviously, we must cut down the full voltage to that required for the filaments and while, when using an ordinary accumulator supply, it is usual to wire all the valves filament in parallel, for filament mains working a series connection is generally to be preferred, provided there are not a large number of valves in the receiver. Running costs will automatically be reduced, since the current will not exceed that required for the highest rated valve, that is, the power or super power, as the case may be.



The Gambrell twin-fuse unit, suitable for incorporation in mains units such as have been described in these pages.

Individual filament control, when desired, must now be effected by placing resistances in parallel with the filaments as in Fig. 5, while the use of resistances between each valve will give the appropriate negative bias tappings. If special intermediate grid bias voltages are not required, the resistances can be omitted, and the negative voltage obtained by connecting to the valve filaments nearer to the negative main, that is in Fig. 5, grid bias for the third valve is secured by joining the grid to the second or first valve filaments.

The calculation of resistance values for the parallel control is very simple. Suppose that the last valve takes ·25 amp., while the other valves are consuming ·1 amp. each, then we must divert ·15 amp. through the resistance. If 6 volt valves are employed then the resistance required is $\frac{6}{15} = 40$ ohms.

It is as well to note here that experiment has proved that some mains, in addition to their normal fluctuations, carry high frequency currents. To suppress these include an H.F. choke in each lead, taking care to see that the chokes are capable of carrying the full current. Ordinary plug-in coils have been found to make quite good chokes for this purpose.

Assuming, therefore, that both H.T. and L.T. are to be derived from the D.C. mains, one form of carrying this into effect is depicted diagrammatically in Fig. 6. This shows lamp resistances for cutting down the H.T. voltage and giving the correct L.T. current, while an extra variable resistance is incorporated in the filament circuit for fine control. The scheme in actual practice has proved quite satisfactory. Under certain circumstances, however, an economy can be effected if we bear in mind that voltage has to be wasted to supply the filaments. Why not use this to furnish the appropriate H.T. potentials, and thus reduce the total number of smoothing accessories? Normally H.T. and L.T. are in series in every wireless set, or at least are interconnected, so that apparently there should be no undue difficulty. This arrangement, together with a novel form of H.T. smoothing and an important detail arising out of series working will be dealt with next month.

The Spotlight Principle.

(*Concluded from page* 300.)

of what they *should* be, due to the polarity of the signal passing through the neon being reversed. This can be easily remedied in one of several ways, either by changing round the leads of the L.F. transformer (where one is used), by changing from grid-leak rectification to anode bend rectification or vice versa, or by adding or subtracting a stage of amplification.

Incorporated with each Baird televisor receiver is a very essential synchronising device to enable the motor to revolve at the same number of revolutions per minute as that at the transmitter. This operates in conjunction with a speed-controlling rheostat. This latter is one of the two controls on the televisor itself. The other regulates the up-and-down movement of the picture after it has been synchronised, to effectively frame it in a central position.

Synchronising.

Synchronism is obtained by bringing the motor up to approximately the correct speed by hand, judging this by the picture, and then the device comes into play and holds it there automatically. If the strips are not in their original order from right to left (an image is scanned from right to left and from bottom to top) —i.e., considering them numerically, supposing we have synchronised at a point where the first strip from the right of the screen is, say, number 12 strip at the transmitter, then the obvious effect is that the picture appears to be split up vertically, and in the case of a face we could see the two ears in the centre and half the nose at each side.

To rectify this it is merely necessary, by means of the rheostat, to spin the disc round until the holes are in their proper relative position.

Possible Effects.

Another possible effect is where the disc is mounted with the spiral the opposite way round to that of the scanning disc. The result is that one sees the image right about left, quite a common occurrence in photography; at least one system of automatic photo-telegraphy has this peculiarity. Reversing the disc, of course, will right this. Further, the neon is normally placed to the rear of the right-hand side of the disc, viewing it from the front, but were it moved around the periphery a picture could be seen at any point. The total number of these would be the same as the number of holes, and each picture as we progressed away from the right position would be more and more incorrect as regards its relationship with the image being televised until the point 180° out of phase was reached. Here the picture would be seen upside down and split in two vertically. This phenomenon is better expounded in Fig. 2.

Secrecy in Wireless Communication.

In passing it may be mentioned that a new means of attaining secrecy in wireless communication is provided by the spotlight system of television, inasmuch as it is only possible to reconvert a transmission into its original components by the use of a receiving disc perforated with the same number of holes as there are in that at the transmitter. The area of the apertures is not so important provided they bear the same proportion to the circumference.

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The New Game

By NOEL SWANNE

IT is absolutely wonderful the way great ideas grow out of little things. When I started making my television set, I never imagined that I should hit upon a plan which I feel certain will do much to keep the population of our lunatic asylums at a low level.

It was this way: stung by the remarks which Marjorie quoted out of TELEVISION, I went to Woolworth's and purchased screws, a screw-driver, some wire, some solder, and about sixteen small dry batteries.

From my stationer I procured various bits of stiff cardboard, and Marjorie lent me her scissors, and I borrowed a Meccano clockwork engine from our neighbour's mechanically-minded son. Then I set to work.

I cut out heaps of diagrams from TELEVISION, and pasted them neatly on post cards. I had between fifty and sixty of these. What I hadn't got on those post cards wasn't worth having.

Those things fascinated me. I classified them, and indexed them. After many trials I found the easiest method was to put all those together which looked like maze-puzzles, and all those which looked like nothing at all, and an occasional shuffle helped matters.

Some of the diagrams were too big for one post card, so I had to cut them in half or in three, and that added to the fun. Marjorie says I never did get them right, but it all depends on what you mean by right.

I reserved a Tuesday evening for the actual building of the set. At seven thirty I turned Marjorie out of the study and told her to go down stairs for a bit, and I would call her when it was working.

Then I . . . er . . . cut a few templates . . . and . . . my finger. I think really I started on the wrong post card. Anyway, the things took longer than I expected. Unexpected difficulties cropped up. There was something about synchronising, and I had not bought one. Of course, a handy man can get over that sort of thing, and at once I decided to leave it till the next day, because I am not a handy man. I felt sorry for Marjorie, sitting down there all alone. I, at least, had my post cards.

While I was clearing up she called:

"Is it working, dear?"

"Not quite," I replied truthfully.

I stood some books over the hole in the cloth, and taking those post cards in my hand, together with my courage and native wit, I went forth to face the storm. That is the worst of these modern houses. Every house ought to have a back staircase.

Marjorie looked very comfortable. The gas radiator was glowing brightly, and no one would have known it was July. I felt annoyed. There had I been shivering up there struggling with mighty things, and all she had done was to read a new novel.

"Have you seen one of my post cards?" I asked her frigidly.

"Seen nothing else for the last week," she replied.

"I mean," I explained, "I have lost one. It's most important. It's . . . it's . . . well, it's a crucial one. I can't go on without it."

"Which one was it?" she asked.

"Oh, it was the one about . . . the one with that dear little curl up in the top right-hand corner, you know, the one which looked like a worm going home . . . late . . . making up excuses as it went."

"I remember it," said Marjorie. "You always put it next to the funny thing like a Chinese hat, because you said the Chinese ate snakes, and a snake was a worm."

"That's it," I said. "It was the best of them all. I should know that wiggle anywhere."

"Are you sure it is not among the rest?"

"Oh, quite," I replied.

"Let's make certain. Give me half of them, and you keep the rest . . . get the card-table . . . now put them down one by one . . . I'll look for the Chinese hat, and you watch out for the worm."

There was a long silence while we did as she said, a silence broken by a wild yell from Marjorie.

"SNAP!" she said.

I trod on the puppy and it did. When we had straightened things out a bit, I asked what the game was.

"Television Snap," said Marjorie.

That's how I made my wonderful discovery. You see the idea, of course. You take fifty-two post-cards. Paste a diagram on each, cut from TELEVISION. The pack is dealt out equally to all players, and then the game is played like that dear old "Happy Families" or "Snap." It is most exciting, because all the diagrams are so much alike—so long as you know nothing about television—that you can get yourself into awful muddles. Before we had been playing ten minutes I had . . . to rescue Marjorie.

In the coming winter months this will become the game of the season. If any one would like to have the first pack with which it was played I am willing to part for a reasonable consideration . . . and there is some wire and solder, and other odds and ends going cheap, too.

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The Television Society

Report of Visit to the G.E.C. Laboratories and British Talking Pictures at Wembley.

ON Wednesday, June 20th, the Television Society held its summer meeting. This took the form of a visit to the General Electric Company's Research Laboratories at Wembley and the British Talking Film Company's studios, also at Wembley.

The journey to Wembley was accomplished by charabanc from Leicester Square—a method of travel which introduced a pleasant spice of adventure. Arrived at Wembley, the piloting car found the recognised road to the laboratories of the G.E.C. "up" in the approved London fashion, only no loop way was indicated!

Road Up!

After an interesting ride through narrow lanes, past new roads in the making, caterpillar tractors doing all sorts of impossible gymnastics over rough ground, and with the G.E.C. laboratories always in view, but still unattainable, the driver of the piloting car gave up following instructions from interested spectators, and said he would find his own way. About this time also the charabanc driver who had loyally followed decided he would find his own way, too. Both duly arrived at the laboratories, but the charabanc was an easy winner with a lead of several minutes.

At the laboratory the party was split up into two groups and put under the care of Mr. G. R. Polgreen and Mr. T. M. C. Lance, both of the electrical laboratory staff, and Miss M. K. Freeth, of the photo-cell department.

Externally, the buildings do not impress the visitor with the sense of magnificence which comes from height and from lavish decoration, but like most good things the best was hidden away to reward those who went forward and explored.

The whole of the laboratories are on one floor, arranged around one main corridor and two wings, a system which provides ample natural light and makes communication between one section and another easy.

Each section has a most complete supply of electric power, gas, air and water, for at set positions in each room are switch panels and taps supplying coal-gas, high vacuum (·5 to 2 mm. pressure), rough vacuum (about 2 to 6 mm. pressure), a general vacuum for chemical work, etc., compressed air at a pressure of 10 lb., water at a pressure of 100 lb., and hydrogen gas. In addition to these there is a current supply to fixed plug points which cover all possible requirements in the way of A.C., D.C., and batteries for almost any electrical purpose.

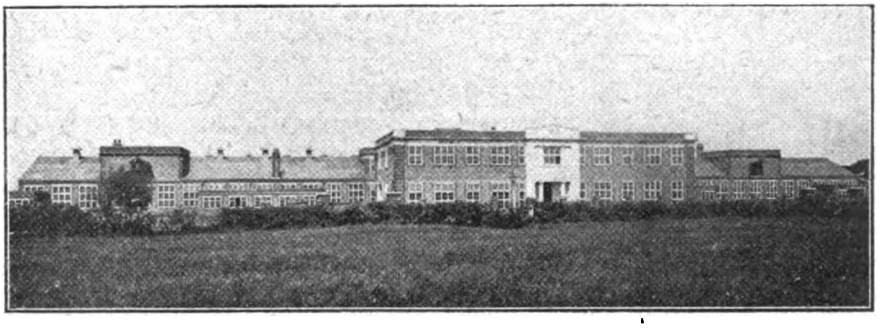
Television Experiments.

A visit was first paid to the photometer rooms, where apparatus for measuring the illumination effects and properties of lamps and lamp fittings was explained in detail. In one room members were very interested to find a simple shadowgraph instrument rigged up, employing a 48-hole disc about 50 cm. diameter. It was wondered if the G.E.C. staff had been trying to pick up the American television transmissions, had been looking in on the Baird transmissions, or were merely doing a little experimental investigation in connection with cells and neon tubes, but no information was forthcoming on these points.

Heating and Sintering.

After a brief glance at the "lamp-life test" rooms, where hundreds of lamps were undergoing life tests, each with its own ticket of comments attached, the party passed on to the section devoted to the manufacture of tungsten wire. Here were seen electrical furnaces whose ovens were made of tubes into which the crucibles containing the tungsten powder are slid and kept in an atmosphere of hydrogen or similar reducing gas during the period of heating and sintering.

Once put into the furnace it is imperative that air and oxygen should not get to the metal while it is hot, so an ingenious method is used to move the crucibles about without having to open the furnace. To each crucible is attached a metal strip carrying a length of stout iron rod. The furnaces, as has already been stated, heat long silica tubes.



General View of the G.E.C. Research Laboratories

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Over these are slipped solenoids which are easily movable. The furnace being sealed up, if it is required to move the crucible the solenoid is moved over the portion of tube where the iron rod lies, the current switched on to the solenoid, and magnetism then makes the solenoid and iron rod one, as far as movement along the tube is concerned.

half a million volts or so. This section also includes an X-ray apparatus used for examining large water-cooled transmitting valves. These are costly to make and when completed little or nothing can be seen of the "insides" by reason of their construction. It is here that the X-ray is valuable, for it makes visible the grid and filament, disclosing any faulty connections or

[Photo by courtesy of G. E. C.

Checking the voltages on the racks of lamps undergoing life test. By means of these exhaustive tests valuable information is obtained enabling the firm to improve their products.

After the tungsten room comes the small laboratory-factory where new processes of lamp manufacture are tried out under factory conditions. Not far away is a similar laboratory for valves.

Unpopular Tests.

In each of these laboratories lamps and valves of all sizes are made and tested. The testing of the larger types of valve is not at all popular with other electrical research workers in the laboratories, for the valve output has to be dissipated, if possible, harmlessly. Occasionally it radiates and plays queer tricks with other pieces of apparatus, gives false readings on instruments it is not concerned with, creates preposterous atmospherics in the radio department, and even does real damage to delicate apparatus.

From this the party went on to the high-tension section, where work is done in connection with voltages of

other defects, without it being necessary to dismantle the valve in any way.

Testing Loud Speakers.

After the high-tension room the general electrical room was visited. Here loud speakers were shown being tested for resonance and similar defects. This is done with a piece of apparatus which gives a steady output at any desired frequency between 20 and 6,000 cycles. The loud speaker is connected to the output terminals and the frequency steadily increased so that any resonance is indicated by a sudden increase in the volume of the note produced.

In this section of the laboratories also a number of photo-electric cells were shown, including the well-known Osram standard potassium cell, an infra-red sensitive cell, and a large special type of cell measuring about 4 in. in diameter and over 19 in. long, which, it was explained, was intended for use in connection with very weak light received from a distance.

Automatic Lighting Control.

Examples were given of two uses to which cells could be put. In one (illustrated in the July number of TELEVISION) a cell with a single valve amplifier was sealed in a weather-proof glass and iron box. It was intended for the automatic control of street lighting. In the demonstration a black cloth placed over the glass portion of the box caused an Osglim lamp representing the street lamps to light. It was explained that the device was so sensitive that it could be made to respond to any sudden darkening, such as a thunder-cloud, and switch on the neon. A chart of its operation during a long period showed it free from breakdown or faults and steady in operation, the curve of switching on and off keeping step with the lengthening days of summer time.

In the other application shown the cell was used to check discs of metal. Any disc not truly circular or with nicks or other flaws in its circumference when placed in the tester caused a signal lamp to flicker. Perfect discs produced no signal at all.

Testing Power Line Masts.

Another piece of experimental plant which interested everyone was the power line mast test ground. This was situated in the open space at the back of the laboratories. The mast to be tested is erected on a concrete platform and subjected to loads and stresses which are applied from steel masts arranged on three sides of it. The loading is recorded on instruments housed in a hut nearby but well out of the danger zone, for the tests are carried to destruction.

Having shown the variety of the experimental work carried out on their numerous electrical products the G.E.C. put their guests "in the laboratory" and subjected them to a very welcome "test" in the canteen, where tea was laid.

A vote of thanks to the G.E.C. was proposed by the Rev. E. Goodchild.

Responding to this Mr. T. M. C. Lance said he thought they would realise from what they had seen that the British G.E.C. was quite capable of holding its own in both the foreign and colonial markets.

From the G.E.C. laboratories the party went to the British Talking Pictures Studio in the Wembley

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Exhibition ground. Here they were welcomed by Mr. C. F. Elwell and Messrs. C. E. Morrison, de Wet, and W. A. Chambers.

British Talking Pictures.

Mr. Elwell explained that he proposed to show them the carpenter's and camera shops, the small studio and recording room, large studio and recording room, properties store, new studio, film laboratory, test and model shop, workshop, dynamos, and battery room and topical lorries.

In this way they would get a good idea of the amount of work that was entailed in the making of a talking film and the various processes through which it went. When they came to the studios they might have to wait until the " shot " was completed, for as the film took up sight *and* sound at the same time every precaution had to be taken to prevent unwanted sounds being recorded. For that reason, when they were taking pictures no one was allowed to enter the studio, or to leave it, in case there might be some noise made.

Possibly also they would not be able to go into the dark room and see the film being developed, as it was essential that all dust should be kept away from that process. Even a person's clothes carried and dispersed a considerable amount of dust.

Effect of Dust.

A very small amount of dust on a film during development, particularly if it got on the sound record portion of it, gave rise to considerable noise.

Apart from these restrictions there was nothing which they could not see.

The party then went round the studios in four groups, each with a guide.

A visit was first paid to the topical cars. These are saloon cars specially adapted for taking " talkies." In the back of the car is fitted a special collapsible camera mount.

Arrived at the scene of operations, a race meeting or a procession or similar outdoor function, the roof of the car is slid back, the camera raised on its pillar well above the top of the car, and when the man with the microphone has arrived at the selected point all is ready to begin.

Inside the car behind the driver's seat the whole of the electrical apparatus necessary for sound recording is housed, including the filament batteries and H.T. supply. The Photeon light, which is actuated by the microphone, and makes the sound record on the film beside the picture, is housed in a special compartment which forms the base of the camera.

In addition to the topical cars, Messrs. British Talking Pictures run a considerable fleet of cars to provide a service to their customers. For this purpose a staff of mechanics are always ready to go to any user who may be in trouble with his " talkie " plant.

In the shops the amplifier plant was seen being built up, the whole, including connections, being most carefully screened with metal to prevent electrical interference. The containing cases are made of five-ply wood, metal covered, and when completed all joints are carefully soldered over. The last stage of the amplifier consists of four L.S. 5 valves in parallel handling 175 m.a. They work four moving-coil loud speakers, although a special type can be made to work six loud speakers.

The photo-electric cell watching the film is directly coupled to a single stage of resistance capacity amplification at the projector. The output from this goes direct to the amplifier, and at this stage the signal is so weak that even on phones it cannot be heard.

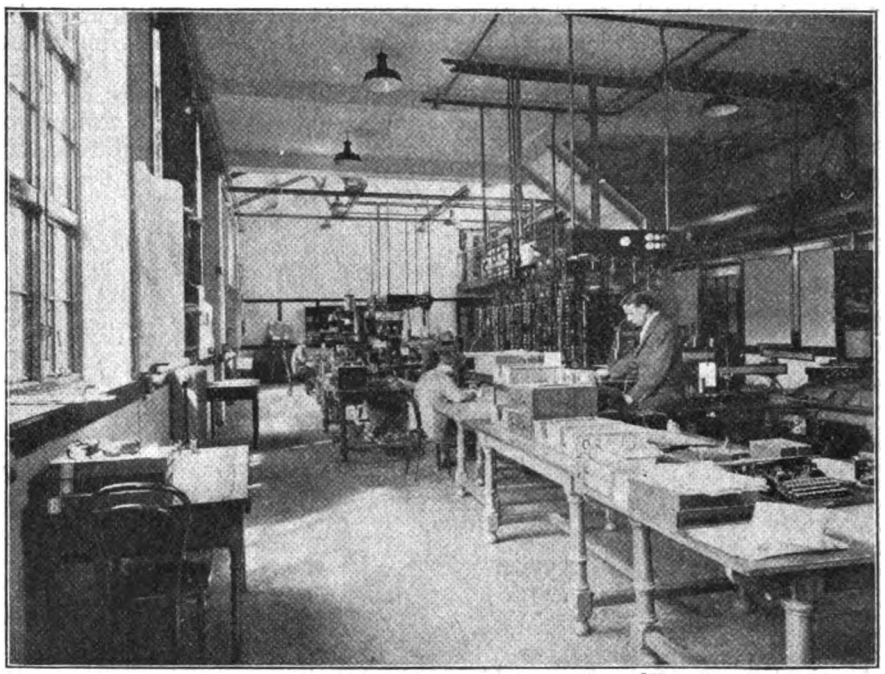
" Talkie " Amplifiers.

The first stage of the amplifier is transformer coupled, followed by a stage of choke-capacity and then, to the output valves, resistance capacity.

The amplifier is contained in the top portion of the case. Under it are housed the filament accumulators, of large capacity to give reliable working, and under these again is the high-tension supply, also from accumulators, to ensure steady, reliable working. It was explained that accumulators were used throughout for both taking and showing pictures, no other method of securing a steady current supply free from fluctuation having yet been found.

In this connection the battery room, where accumulators are charged, overhauled, repaired, and generally looked after, was shown. A number of small generators have been installed, and charging goes on almost continuously for users' accumulators, in addition to those required in the studios.

After the battery room the party moved on to the camera room. Here ordinary cinema cameras are fitted with the sound-recording apparatus which puts the sound record in a narrow band beside the picture, only the sound record is retarded 21 pictures after the picture to which it refers. This is necessitated by the



[Photo by courtesy of G.E.C.

The Electrical Room where work on valves, amplifiers, and wireless problems is tackled scientifically. Note the elaborate apparatus necessary for this purpose.

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fact that the film passes the lens first before going before the light. The film, too, has to be jerked past the lens after each exposure, while for the sound it has to run steadily. The 21 pictures lag forms a convenient loop which absorbs the jerk of the picture taking, and makes it possible to have a steady traverse for the sound. The same applies when the picture is being shown.

The Projector Room.

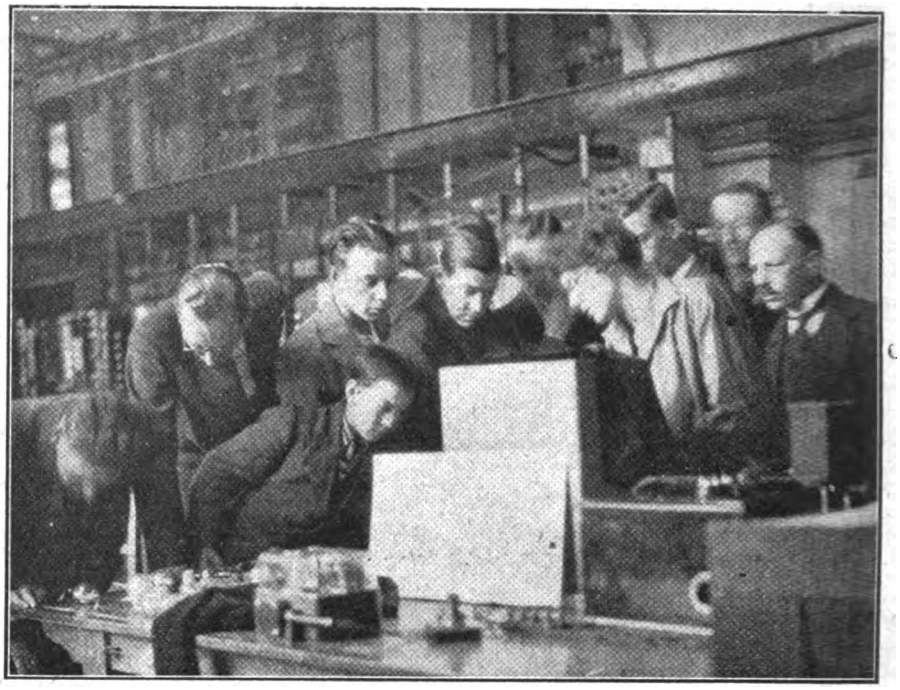
The projector room was next visited. Here, as in the camera room, ordinary projector lanterns are fitted with the special "talkie" attachment.

These attachments are in each case made by the company, and when fitted are given a 24 hours' continuous run under close supervision. During this time the necessary adjustments are carried out, and any defects found and rectified.

Loud speakers have a room to themselves, where they are tested. This is another item which the company build specially for themselves. Ordinary moving-coil loud speakers and speakers of the exponential horn type were found to be unsuitable, so the problem was tackled, and a type of moving coil with a particularly rigid suspension was evolved.

Talking pictures are rarely made straight through at one taking, but are, as in ordinary film practice, built up of a number of "shots" taken at different times.

This introduces a photographic difficulty, for it is almost impossible to get the same density of picture over a number of exposures, although the sound recording is always the same, as the recording light does not vary.



Members inspecting the demonstration of industrial applications of Osram photocells. The street lighting unit is on the table in the foreground.

If sound and picture were always taken on the one film, the printer, when trying to get a picture of even density throughout its length, would necessarily vary the density of the sound record. Any variation here causes an increase or decrease in the volume of sound produced, which in its effect on the audience would be worse than a picture of varying density.

How this is overcome was explained when the studios and printing rooms were visited.

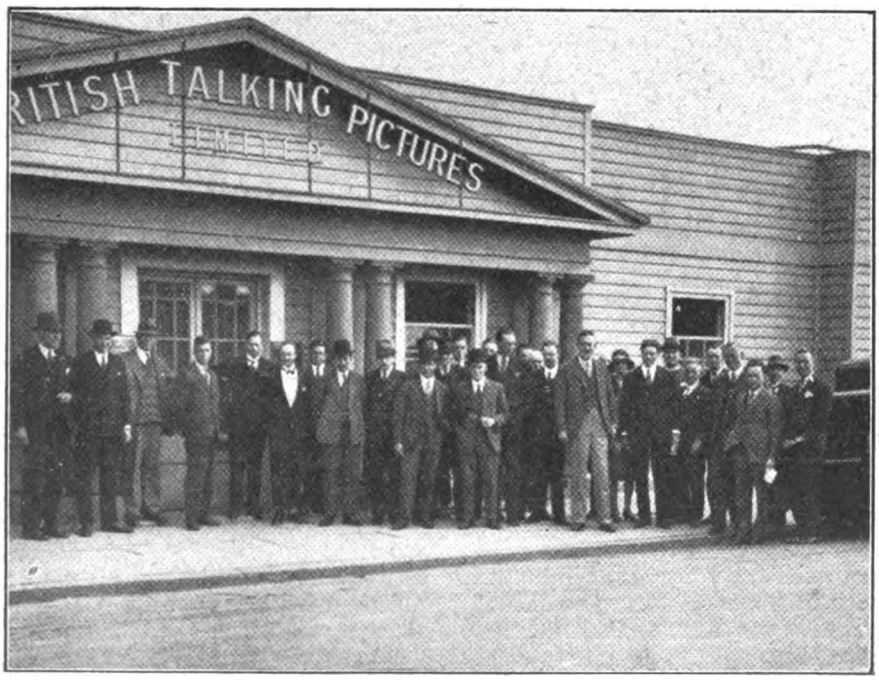
The Printing Room.

In the studio the picture is recorded on one strip of film and the sound on another, entirely separate. The motors driving each strip are carefully synchronised, and the beginning of each combined "take" is clearly marked.

Both strips are developed separately.

When printing is done the negatives which make up the complete picture are examined in the order in which they will come, and the examiner marks on a card their varying density.

The printing is done with a special lamp and lantern. The lamp is controllable as to the amount of light it gives, and this is varied in accordance with the instructions placed on the examination card.



The visiting members photographed outside the entrance to British Talking Pictures, Ltd. Mr. C. F. Elwell is fourth from the right.

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The portion of the film which will carry the sound record is blanked off while the picture is printed.

When the sound record is printed on the picture it is started 21 pictures from the beginning of the film, for reasons which have already been given, and the whole of the sound record is printed off at once, no variation in the light being made.

From the printing room the film passes to the developing room, where it is passed steadily through the developer, washing, fixing and final washing tanks, then through a light-tight port in the wall, and so into the drying room, where warm dry air completes its final drying.

Development.

The process of development is interesting, for it is entirely automatic and continuous, the attendants merely having to watch the temperature of the various baths to see that they do not rise or fall beyond certain set limits—if they did the film would be either over- or under-developed—and see that no breaks occur in the film.

The strip, when it comes into the room, is fed down into the developer under a pulley, then up to a pulley overhead, down into the developer again under another pulley, up over a further pulley overhead, and so on. In this way the film passes steadily in a long spiral through the developer, the steady movements down into the solution, and up out of it to the pulleys overhead, securing even development and keeping the solution in motion. Just before it leaves the developer, air suckers remove surplus solution. When it has passed through the brief wash, and before entering the fixing bath, suckers again remove surplus water, an operation which is repeated after the fixing-bath, and after the final washing.

This plant can, and does, regularly handle 12,000 feet of film a day. At the end of a day's run, to save the labour of feeding new film over the many pulleys when the next developing starts, old film is tacked on to the end of the last piece of film and run right through to the drying room.

When work restarts the operator has merely to clip the new film on the end of the old film already standing in position, start the motor carrying the film through the baths, and everything goes on as though there had been no stop.

In the studios, the sound-tight boxes housing the sound recorder and cameras, the latter with a plate glass front, were shown. Picture studios, when sound is recorded, have to be made like broadcast studios, and carefully draped with curtains. In some cases when "close-ups" are being taken, additional curtains have to be hung round the actors, to concentrate the sound on to the microphone and prevent it echoing round the studio.

The Property Store.

An interesting side-line to the studio is the "Property Store." Here practically everything that may be wanted to make a scene or to complete one is stored. Motor-cars, aeroplanes, handsome furniture, armour, all stand in jumbled array, and nearly all of it is made of three-ply wood. This side of picture-making has been brought by the stage carpenter to the standard of a fine art. Should a particularly handsome doorway or castle entrance be wanted and no suitable place be convenient, the stage carpenter builds one either in the indoor or outdoor studio out of three-ply wood, and no one, unless they are in the know, can detect the fraud. When it has served its purpose it goes into the "Property Store."

If it is a grand piano or fine heavy dining-table that is required, the same material is used, and when taken it looks like the real thing.

When the party visited the large studio, a portion of an ancient street was being built of such unlikely material.

New Films for Old.

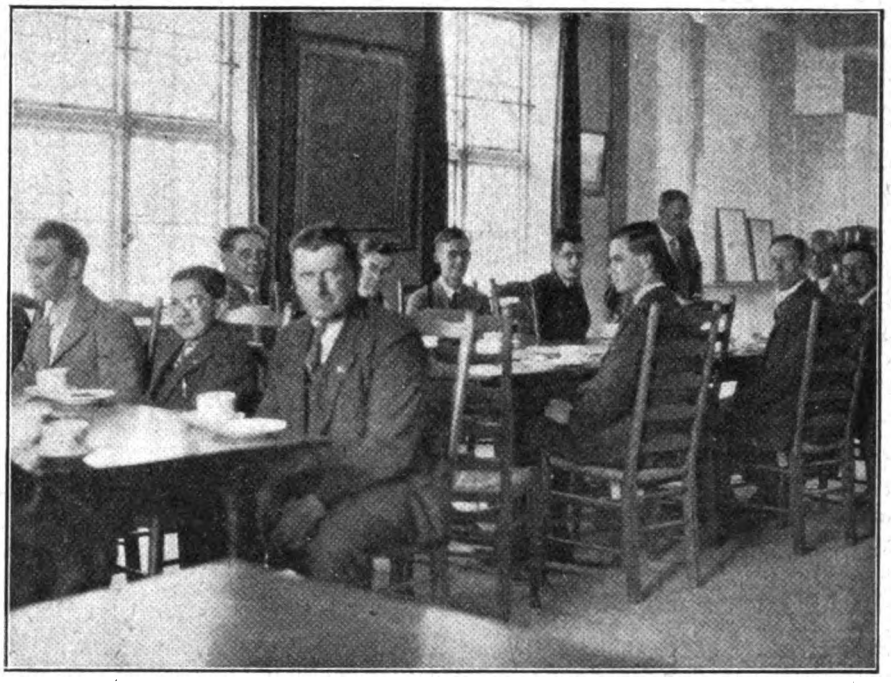
Besides making new film, sound can also be put on old silent pictures. For this the picture is shown in the studio, while the orchestra, singers or actors watch it and produce the required sounds, which are recorded.

The old picture and the new sound record are then printed together in exactly the same way as a new picture.

Of the many other branches of talking picture production which were seen, one of the most interesting was that dealing with new ideas.

These, to whatever they relate, are made up and given a lengthy trial under working conditions, before being incorporated in the standard apparatus.

So many members of the Television Society applied for tickets to take part in these two visits that, at a later date, a second group will visit both places.



A section of the party at tea in the canteen of the G.E.C. Research Laboratories, where all the latest electric cooking appliances and refrigerators are used to prepare the meals.

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Can Frequency and Phase-Change Modulation Reduce Interference?

By J. H. OWEN HARRIES, A.M.I.R.E.

Introduction.

TO transmit a varying current, say speech or television signals, from place to place, the obvious way is to send it straight through the line or other channel between the transmitter and receiver. But sometimes, as in radio working, the channel will only pass a certain limited band of frequencies, which are not those of the current to be sent. Then the remedy is to modulate a carrier current by the signal current. The frequency of the carrier current is chosen to be within the band which can be passed by the channel to be used, and the modulating signal current is superimposed on it by causing some characteristic, usually the amplitude, of the carrier wave to be a function of the instantaneous amplitude of the modulating current (Fig. 1). At the receiver we separate the carrier from the signals and utilise the latter as required.

Amplitude Modulation.

But unfortunately when we vary the amplitude of the carrier we also cause it to spread over more than its original frequency band. In wireless working this means that it will overlap and interfere with other bands.

We express this mathematically by resolving the modulated wave into component "side bands" which show the actual spread in terms of the frequency of the modulation. The higher the latter, the greater the spread. Actually the spread of the carrier is equal to twice the modulating frequency, *i.e.*, if the carrier frequency f_c=1,000,000 cycles, and the modulating frequency f_M=10,000 cycles, the carrier will occupy a band from 1,010,000 cycles to 990,000 cycles, a spread of 20,000 cycles.

Now for television and other purposes f_M may run into hundreds of thousands of cycles; hence the spread will be far more than the 10,000 cycles or so allowed to the broadcasting stations* by International agreement.

* For further information see the series of articles entitled "Bridging Space," by J. Wiseman, in this Magazine.

The problem is therefore to try and reduce this spread.

Side Bands.

In the rest of this paper the arguments will be presented in physical language as far as possible, but for the quantitative work a knowledge of the elementary principles of rotating vectors and harmonic analysis will be assumed.†

FROM time to time we have referred in this Journal to the present state of overcrowding in the ether and to the urgent need for wireless engineers to devise some new method of modulation which will render radiotelephony less extravagant in its demands for space or frequency bandwidth in the ether. This need is particularly imperative in view of the imminence of the extensive addition of television broadcasting to the already established sound broadcasting services. In the following article Mr. Harries discusses quantitatively the possibilities of various alternative systems of modulation which have been suggested recently.

As everyone knows, the amplitude modulated wave equation is—

$$i=I_c \sin \omega t\,(1+K \cos pt) \quad \ldots \quad (1)$$

where

I_c=the maximum value of the carrier current.

ω=the angular velocity=$2\pi f_c$.

K=a constant controlling the depth of modulation.

p=the angular velocity of the modulating current=$2\pi f_M$

† Can be obtained from "An Introduction to Mathematics," by Prof. Whitehead, and from "Elementary Mathematics for Wireless Telegraphy," by S. J. Willis.

and this expands into three (angular) frequencies—the carrier ω and two side bands $(\omega+p)$ and $(\omega-p)$ in this manner:—

$$\begin{aligned} i_c &= I \sin \omega t\,(1+K \cos pt) \\ &= I_c \sin \omega t + KI \sin \omega t \cos pt \\ &= I_c \sin \omega t + \tfrac{1}{2}KI\,[\sin (\omega+p)t \\ &\qquad + \sin (\omega-p)t] \\ &= I \sin \omega t + \frac{K}{2} \sin (\omega+p)t \\ &\qquad + \frac{K}{2} \sin (\omega-p)t \quad \ldots \quad (2) \end{aligned}$$

That is, the carrier acts to a circuit which has its response a function of frequency (e.g. a tuned circuit) as if it (the carrier) is the combination of these three frequencies ω, $(\omega+p)$ and $(\omega-p)$.

Frequency Modulation.

It has been felt that if we could find a way of modulating the carrier which does not "affect its amplitude" we could avoid this spread, or at any rate reduce it.

The methods suggested have been—

(*a*) To vary only the frequency of the carrier by the modulating current.

(*b*) To vary only the phase of the carrier by the modulating current.

Take (*a*) first. A commonly suggested way of doing this is by varying the tuning capacity of the transmitting oscillator (Fig. 2). Using the usual mathematical convention to indicate an unspecified relationship, it is usual to define this way of modulating by

$$f_c=F(i_M)$$

where the symbol f_c has the same meaning as hitherto, and i_M=the instantaneous value of the modulating current.

But this statement is incorrect, for "frequency" is a term only applicable when the current it refers to is periodic (i.e. steady). If it is varied by modulation this term has no meaning. The solution of this difficulty is to define "frequency" modulation as "angular velocity" modulation, i.e. where—

$$\omega=F(i_M)$$

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The usual statement that "amplitude remains constant" is then also capable of interpretation, for it may be taken to mean that the rotating vector representing

$$i_c = I_c \sin \omega t$$

(the angular velocity of which, (ω), is varied by modulation) is of constant length.

The value of ω at any instant $= \omega_{inst}$ divided by $2\pi = \frac{\omega_{inst}}{2\pi} = f_{inst}$ may be termed the "instantaneous frequency" of the carrier, but we must remember there is nothing to show that the range of variation of this is the extent of the "interference band width."

Phase Modulation.

This method of modulation may be defined as when the phase difference of the carrier current at any instant is proportional to the instantaneous value of the modulating current, i.e. where

$$\varphi = F(i_M) \quad \ldots \quad (3)$$

But the "phase difference" with respect to what? The answer is that we may define φ as the difference in phase between the carrier and an imaginary current of the same frequency as, and having no phase difference to, the carrier before modulation.

It is perhaps not immediately obvious that a change of phase must cause a change of angular velocity (i.e. "frequency") also during the time over which the change of phase occurs. Drawing a graph such as Fig. 3 will show this immediately, for the change in φ at (a) on the time base obviously lengthens the periods of current at that time, and, of course, the longer the periods the lower the instantaneous frequency.

Let the maximum value of i_M cause a change of $\frac{2\pi}{a}$ of a period of the carrier.

Then the instantaneous angular velocity of the carrier will be given by

$$\omega_{inst} = \omega_0 + 2\pi \left(d \frac{\frac{2\pi}{a}}{dt} \right) \quad \ldots \quad (4)$$

Where ω_0 = the unmodulated carrier frequency—i.e. the change of ω is given by the rate of change of φ with time in terms of the angular displacement of the current vector.

From ordinary trigonometry

$$\frac{di_M}{dt} = pI_M \cos pt$$

hence from this and (4) and by substituting $\frac{2\pi}{a}$ for I_M we have—

$$\omega_{inst} = 2\pi \left(p \frac{2\pi}{a} \cos pt \right) + \omega_0 \quad \ldots \quad (5)$$

Phase modulation therefore produces a change in ω just as in the case of "frequency" modulation, except that in the former case the maximum value of the variation in ω is a function of p, and is a cosine instead of a sine function of i_M

In endeavouring to examine the properties of these two forms of modulation as regards their interference band widths we may therefore

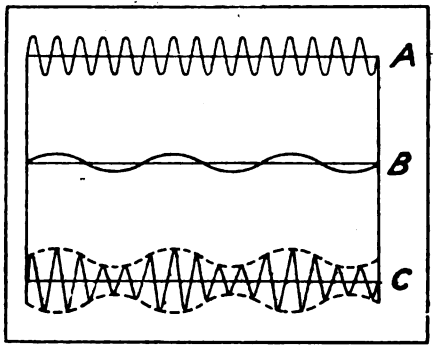

Fig. 1.
AMPLITUDE MODULATION.
A = unmodulated carrier wave.
B = modulating current.
C = modulated carrier wave.

confine ourselves to straightforward "angular velocity" modulation, knowing that both methods reduce to it in their final results. This is a very convenient simplification.

Physical Meaning of Side Bands.

Let us first consider what "side bands" really mean. That there is a good deal of confusion in people's minds on this subject has been shown by the recent correspondence in a contemporary magazine.* The correct meaning will be briefly given here, but readers interested are referred to the letters for an extended treatment.

The question of the "reality" of the side bands is nonsense. The only reality is the flow of electrons in the circuit.

Imagine that we have any electrical circuit on which a voltage wave is impressed. The voltage may be that induced by a wireless wave, and the circuit may be the tuned aerial of the wireless receiver. Or the voltage may be the E.M.F. of an A.C. generator, or the potential produced by the flow of current from a valve through a resistance connected across the circuit the "response" of which we wish to examine.

The "response" is given by finding the current produced by unit voltage (the true meaning of the terms "resistance" or "impedence"). Then, obviously, to find the current I produced by any given voltage E, we divide E by R; or in other words we have the familiar Ohm's law equation

$$\frac{E}{R} = I$$

and its well known variations allowing for phase lag or lead.

Now let our induced voltage be a "sine-wave." The mathematicians have studied the properties of this particular form of voltage time curve, and, knowing the effective inductance, capacity and resistance we can, by using the data they have found for us (as regards the impedence of the circuit

$$Z = R + \left(j\omega L - \frac{1}{j\omega C} \right)$$

to a wave of this sine shape) easily find the current, or "response," of our circuit to any particular value of our voltage sine wave. This is quite straightforward.

But suppose the voltage wave is not of sine form? Then our mathematical data is no use to us and we must cast about for another way out.

First, what constitutes a departure from sine wave form? The answer is any departure from "periodicity" of the sine wave, which means the exact similarity of every sine wave of the train of impulses to the others.

Thus the variation of amplitude due to modulation of the carrier wave in Fig. 1 (C) makes the sine-wave formulæ inapplicable. Also the variation in frequency in the wave illustrated in Fig. 6 invalidates this data. In other words, to come down to the particular case in hand, *we cannot, as already mentioned, speak of the "frequency" of any carrier wave unless it is unmodulated,* i.e. unless it is not carrying any signals. How, then, can we find the response of a circuit to a modulated carrier?

Harmonic Analysis.

To solve this problem let us consider the basic case of any non-sinusoidal, or "complex" voltage wave form.

* *Experimental Wireless.* Correspondence Section. Nov., 1928, and Jan., Feb., Mar., Apr., May, 1929. (Mr. W. B. Lewis's summing up in the latter issue is especially instructive.)

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The response of any receiving circuit is expressed by a graph (Fig. 4) of current against frequency (sine wave voltage), i.e. a graph of the current produced by a unit voltage sine wave at each frequency over the range.

But our voltage is not a sine wave and we therefore cannot apply it to this graph at any point on the frequency axis to find the resulting current, or "response," at that frequency, as we could if the impulse was sinusoidal.

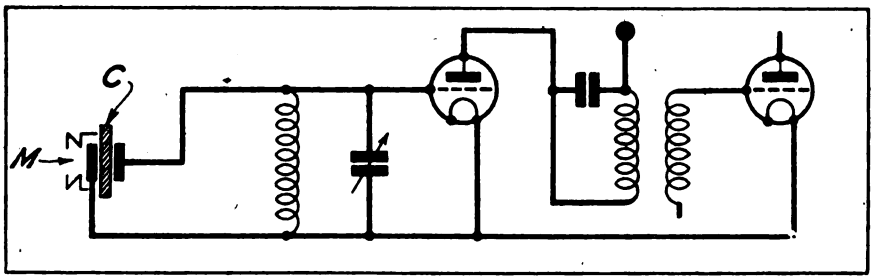

Fig. 2.
A "FREQUENCY" MODULATING CIRCUIT.
The transmitter carrier frequency is held constant by the crystal C when no modulation occurs. The sound waves impinging on the microphone M move the electrode in it, and thus vary the carrier frequency. (Pat. No. 295957, issued to J. Robinson.)

The way out is just this. We take advantage of the fact that the non-sinusoidal voltage can be imagined to consist of the sum of certain sine waves of various frequencies, just as in mechanics any force can be resolved into a number of (probably) imaginary component forces.

These component frequencies are those which, if actually supplied at the same time to the circuit with the correct relative phase angles between them, would add up to give the complex voltage wave we are studying; though this latter may actually have been produced in quite another way.

Then from our frequency/current graph (Fig. 4, for instance) we can find the current produced by each component sine wave frequency of the complex voltage.

These resulting component currents are then added up, not forgetting their phase differences over the range of frequencies covered by the graph. This sum is then the actual current produced.

Thus the components of complex currents or voltages are mathematical fictions, for the only reality is the resulting flow of electrons, or in other words the *sum* of the current components. The fact that by selective circuits we can eliminate, or make negligible, some particular "bump" or "hollow" in the current wave, which may be equivalent mathematically to removing all the components except one, does not make it any the less ridiculous to think of the components of the complex wave (with its "bump" left in) as "real."

For example, Fig. 4 shows the familar current/frequency curve of a tuned circuit in a wireless receiver. We cannot apply the non-sinusoidal voltage (induced by the waves in the ether) shown in Fig. 1 (*C*) or Fig. 3 to such a curve for its base line refers to sinusoidal periodic currents only (remember that "periodic" means constant amplitude *and* frequency). But as shown in sec. 3 we can find the component "side bands" or frequencies of the modulated wave of (Fig. 1 (*C*)) by harmonic analysis.

Suppose these components have frequencies of (*a*), (*b*), and (*c*) cycles, as marked on the base of the graph (Fig. 4). Then the current produced is given by the sum of (*a*)(*d*), (*b*)(*d'*) and (*c*)(*d''*), the three imaginary component currents. Suppose, however, that the side band frequencies were at (*e*) and (*f*), outside the extent of the response curve of the receiving circuit, then they will not produce any current, and the only current flowing will be that produced by the carrier component (*b*) of the wireless voltage wave.

If one side band (*f*) came into the range of the response of another receiver tuned to a second transmission it would interfere with that transmission. Similarly, by using a selective receiver we may boost up any of the components of the wave at the expense of the others. Since the modulations or variations (i.e. non-periodic nature) of the current wave depends on the sum of the components we can "smooth out" the signals altogether by receiving (*b*) only as above.

In just the same way we can multiply the frequency of a current by distorting the voltage wave form, and by selecting one of the imaginary components, or harmonics, and, by suppressing the others, make this component only a real current. Many people have no difficulty in visualising this latter process, but fail to see the exactly similar nature of the "side bands" in modulation.

In physical language we may consider this filtering action as a result of the circuits in question tending always to make the current/time graph follow a periodic sine wave form within certain limits.

Thus a tuned receiving circuit smooths out variations in the amplitude of the wave due to modulation if they occur rapidly enough to distort the individual wave seriously from the periodic sine wave form, which illustrates the fact that the choice by mathematicians of the sine wave as our fundamental component in the analysis of wave forms is by no means artificial or arbitrary.

Side Bands in Frequency Modulation.

Will frequency modulation have these side bands? That is, does it cause an appreciable departure from periodic sine wave form of the carrier wave, such as will be split up into components by the different tuned circuits of the receivers in use in range of the transmitting station?

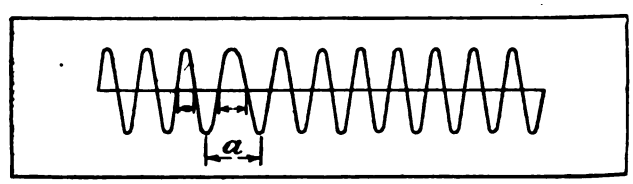

Fig. 3.
Illustrating how phase-change modulation produces a frequency change at the time of the change of phase.

It would seem from the previous physical arguments that it will. The quantitative answer is found by analysis of the basic equation for angular velocity modulation

$$\omega = F(i_M)$$

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which may be written quantitatively as

$$i_s = I_s \sin(\omega t + k \sin pt) \quad \ldots \quad (6)$$

We may expand this as follows*

$$i_s = I_s \sin \omega t \cos(k \sin pt) + I_s \cos \omega t \sin(k \sin pt)$$

With k (the depth of modulation)† =less than 1/10, we have

$$i_s = I_s \sin \omega t + I_s k \cos \omega t \sin pt$$

$$= I_s \sin \omega t + \frac{I_s k}{2} \sin(\omega + p)t - \frac{I_s k}{2} \sin(\omega - p)t \quad \ldots \quad (7)$$

this means that we have a carrier of frequency ω and two side bands $(\omega+p)$ and $(\omega-p)$, just as in the case of amplitude modulation (see equation (2)) except for the phase of the side bands. Where $k > \frac{1}{10}$ even more interference than with amplitude modulation will be caused, theoretically.

Since in practice i_M is a complex wave itself the carrier will occupy the whole band of $\frac{2p}{2\pi}$ cycles, if $\frac{p}{2\pi} = f_M$ is the top modulating frequency, and the receiver used must be capable of receiving over this range, i.e., the receiver tuning circuit response curve must extend over this gamut.

If $\frac{p}{2\pi}$ is up to 10,000 cycles or so, this gives no serious trouble, but for higher frequencies there simply is not sufficient room in the wave bands allowed to broadcasting.

Apart from this last we could, of course, make a receiving circuit having a flat response over any width we please—indeed the author has devised a method of eliminating tuned circuits for the purpose of receiving over wide bands and cutting out undesired frequencies outside the side bands, but in the present overcrowded condition of the broadcast waves it is of no help in our difficulty.

Effect of Side Bands in Angular Velocity Modulation.

It is obvious that though side bands are produced by frequency and phase change modulation they cannot act on the carrier in the same way as in amplitude modulation, or we should be able to use the same methods for de-modulating both waves—which we know is not the case.

What is the difference between the fully analysed expressions for the two forms of modulation? On comparing equations (2) and (7) we see that there are two main differences.

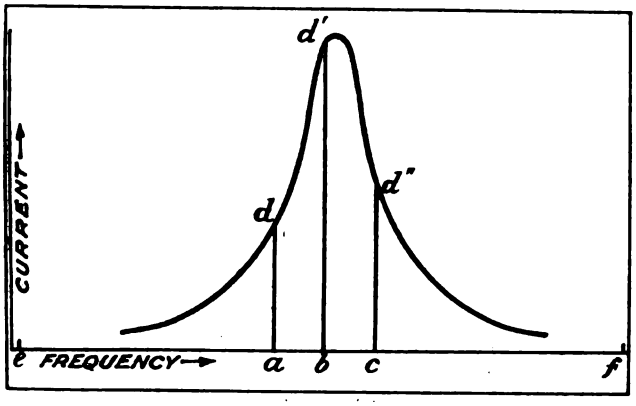

Fig. 4
Graph of frequency against current of wireless receiving circuit.

The amplitudes of the side bands are different. This does not account for our difficulty.

The sign before the expression for the $(\omega-p)$ side band is negative for frequency and phase modulation, instead of positive as in the case of amplitude modulation.

Now we know that the physical meaning of the equation for the latter case (2) is that at the receiver the side pulsations $(\omega-p)$ and $(\omega+p)$ combine with ω in producing the pulsation p (the modulation) by heterodyning, i.e., the amplitudes of the beats of $(\omega+p)$ with ω and $(\omega-p)$ with ω add algebraically and positively (add arithmetically). But in the case of equation (7) the minus sign changes this, for we see by analogy that the speech currents add algebraically and negatively (subtract arithmetically), that is, as long as they are of equal amplitude the beats of the side bands with the carrier cancel out and "amplitude modulation" of the carrier is not produced.

But if the side band currents are of unequal strength in the receiver they will not cancel, and will produce amplitude modulation proportionally to their algebraical sum (or arithmetical difference).

This is the analytical explanation of the process often suggested for de-modulating a frequency modulated carrier by receiving it on the side of the response curve of a tuned circuit (Fig. 5). In the figure let (a) indicate the carrier frequency and (b) and (c) the side band frequencies respectively. Then, just as in Fig. 4, we have the resulting amplitudes respectively $(a)(d')$, $(b)(d'')$, and $(c)(d''')$. The side bands are unbalanced and therefore amplitude modulation results, which may be detected by rectification as usual.

But if the band width $(b)(c)$ was wider than the slope of the curve, the side band components would vanish and the modulation with them. Now the slope of the curve of a normal receiving circuit only extends over a band of 10,000 cycles or so.

$f_M = \frac{p}{2\pi} = \frac{\text{bandwidth}}{2}$, hence we have

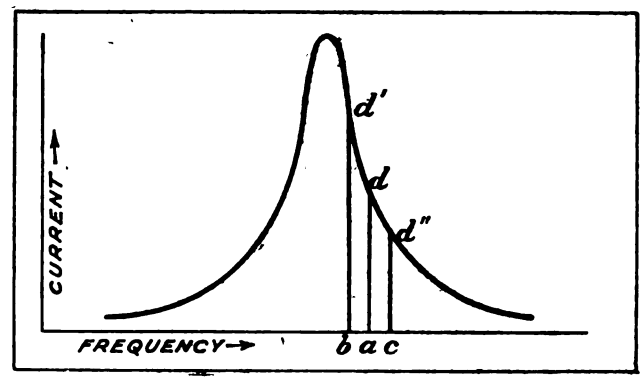

Fig. 5.
Conversion of frequency modulation to amplitude modulation at the receiver.

* This analysis has been given in full in Mr. N. E. Holmblad's letter on 'Frequency Modulation" in *Experimental Wireless*, p. 260. May, 1929. Vol. VI.

† k is actually an increment to the angular displacement of the rotating vector, and the equation, therefore, refers really to phase-change rather than frequency modulation.

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another upper limit to the modulation frequencies which it is possible to transmit by the usually suggested technique of frequency modulation.

Then, too, as the tuned circuit has two sides to its slope we shall be able to use only half the available permissible broadcast station wave band or the next station will interfere. This reduces f_M theoretically to $\frac{10000}{2} \times \frac{1}{2} = 2500$ cycles only, unless we leave one side band outside the allowable wave band altogether, which is all right for us, but will cause interference to other people.

Simpler Analysis of Angular Velocity Modulation.

But all this, one may complain, is rather in the air in more than one sense for those to whom trigonometry is not meat and drink. Let us endeavour to show the distortion of wave form and the wide spread of interference in a more concrete way, even if it must be less quantitatively.

Start by considering the signal current, say the output from a theoretical "televisor" having a component top frequency f_M of hundreds of thousands of cycles.*

Here we have, in transmitting this frequency, from the ordinary theory of alternating currents

$$i_M = F(f_M) \quad \ldots \quad (8)$$

That is, the imaginary rotating vector generating i_M is revolving at hundreds of thousands of times a second, therefore, from the known quantitative form of (8), $i_M = I_M \sin pt$, the current must vary hundreds of thousands of times a second also.

Now cause i_M to modulate the carrier frequency. By definition we have

$$\omega = F(i_M) \quad \ldots \quad (9)$$

i.e., we have, from the known form of this (6), the angular velocity of the carrier being varied to a certain extent (called the depth of modulation k) at the frequency of f_M.

Finally we have the function for the carrier current

$$i_c = F(\omega) \quad \ldots \quad (10)$$

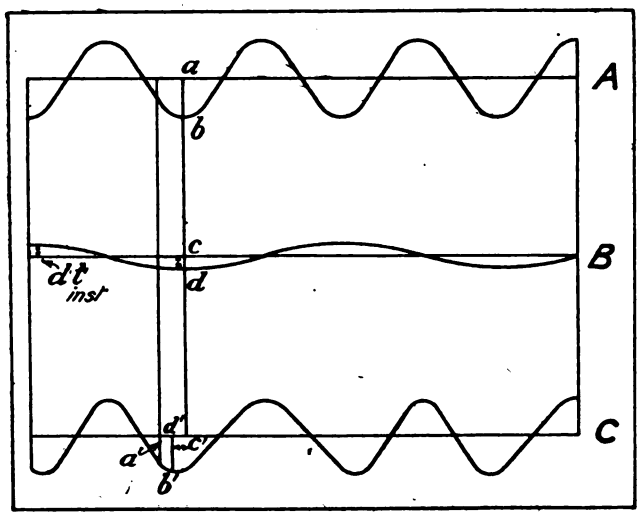

Fig. 6.
GRAPHICAL REPRESENTATION OF FREQUENCY MODULATION.
A = unmodulated carrier wave.
B = modulating current in terms of
C = modulated carrier wave.
(distances cd and $c'd'$ exaggerated for the sake of clearness.)

Now this expression means that (the other factors in the equation this corresponds to being constant, or steadily varying) if we add to one of the two factors i_c or ω, the meaning of the = sign is that the other is also varied to some extent.

The sinusoidal variation in ω at the high frequency of f_M corresponds at any instant to adding or subtracting a small "bit" $d\omega$ to or from ω, and doing so at this high frequency. As explained in the last paragraph this must mean that i_c is also varied at this high frequency—in other words there can be no such thing as varying the angular velocity (frequency or phase) of a carrier *without varying also the current wave from the sine-shape.* This, as already explained, must mean the introduction of component frequencies, or "side bands," the values of which we have already found trigonometrically in section 8.

Graphical Representation.

The time taken by one period is $\frac{1}{f_c}$ and $\omega = 2\pi f_c$ hence we may represent the result of modulating the frequency of a carrier graphically as in Fig. 6, which was constructed as follows.

Graph A is the carrier as it would be if unmodulated.

Graph B represents the modulating current in terms of the change in frequency produced. (Mathematically

$$dt_{inst} = \frac{1}{f_c} M \sin pt).$$

Graph C represents the modulated carrier and is drawn by copying A with the distances between its ordinates reduced by the height of B at the same instant of time.

For instance take the ordinate ab on A. Where the extension of this to B cuts the time base, the modulating instantaneous amplitude dt_{inst} is cd and is negative.

Therefore measure off $a'b'$ on c' equal to ab but displaced from the extension of the ordinate ab to c' by $c'd' = cd$.

This construction also allows one to study any given modulating wave form by drawing it in at B, and shows the principles of frequency modulation more clearly than by simply plotting equation (6) for a sine wave of i_M.

Need for a Perfect Modulator.

We must note that all these equations infer a perfect modulating device, i.e., where ω only, and *not* also the length of the carrier rotating vector, is modulated, for otherwise still more interference will be produced.

The author is not aware of any published method of attaining this result.

It is all very sad to thus demolish one's hopes of a solution to the wave band problem on the lines that have been published of frequency or phase change modulation of radio frequency carriers. Would that the writer were wrong!—anyway he hopes that others will write and give their opinions on the possibility of a way out of this unhappy *cul-de-sac.*

* "A Quantitative Analysis of Television," by J. H. O. Harries. TELEVISION, May, 1929, p. 106.

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THE CONSTRUCTION OF EXPERIMENTAL TELEVISION APPARATUS

Part III

By A. A. WATERS

Mr. Waters, in collaboration with Captain F. Wilson, recently demonstrated before the Television Society a Shadowgraph Transmitter and Receiver which they had designed and constructed. The following is the third of a series of articles which Mr. Waters is writing for "Television," giving constructional details and information of value to amateurs.

IN the preceding two articles of this series we have dealt with tools and equipment, and also with the construction of scanning discs. The next important piece of apparatus we have to consider is the Projection Lamp.

There are many ways of arranging for a light source suitable for television work, but if it is desired to keep down the cost of current it is essential to make the fullest use of one's light.

When experimenting with the single-disc Transmitter and Receiver a 220-volt, 500-watt gas-filled lamp was used, with a reflector having a focus of 6 in. In our earliest experiments we found that covering in the light much improved the results we obtained, and I have indicated our method in Fig. 1.

"Trial and Error."

We decided, after a time, to use a projection lamp giving a concentrated beam about 2½ in. diameter. Our knowledge of optics, however, being less complete than it might have been, we had to proceed chiefly by trial and error methods; those of my readers who are conversant with the subject will, of course, be spared a lot of the "donkey work" we had to undertake in this direction.

We found ourselves up against the difficulty that an image of the lamp filament appeared on the object illuminated. Nevertheless, we found that the beam gave greatly improved results as compared with our first lamp which threw no beam. I would suggest that the experimenter adopts this "beam" method, and I will describe a suitable projection lamp for his purpose. If, however, an ordinary "magic lantern" is available it will serve admirably, and it will not be necessary to make the lamp I am about to describe.

As it is generally required that experimental apparatus should be capable of being built cheaply and quickly, though, of course, efficiently, it is convenient where possible to use articles that can be converted with a minimum of trouble.

My readers will hardly be surprised, therefore, to learn that the case of our Lantern is an ordinary 7-lb. biscuit tin.

The following method of procedure is recommended. First, mark the centre of the bottom of the tin and drill a hole 1/16 in. diameter. Using the trammels referred to in earlier articles, cut a hole smaller in diameter than the diameter of the lens used

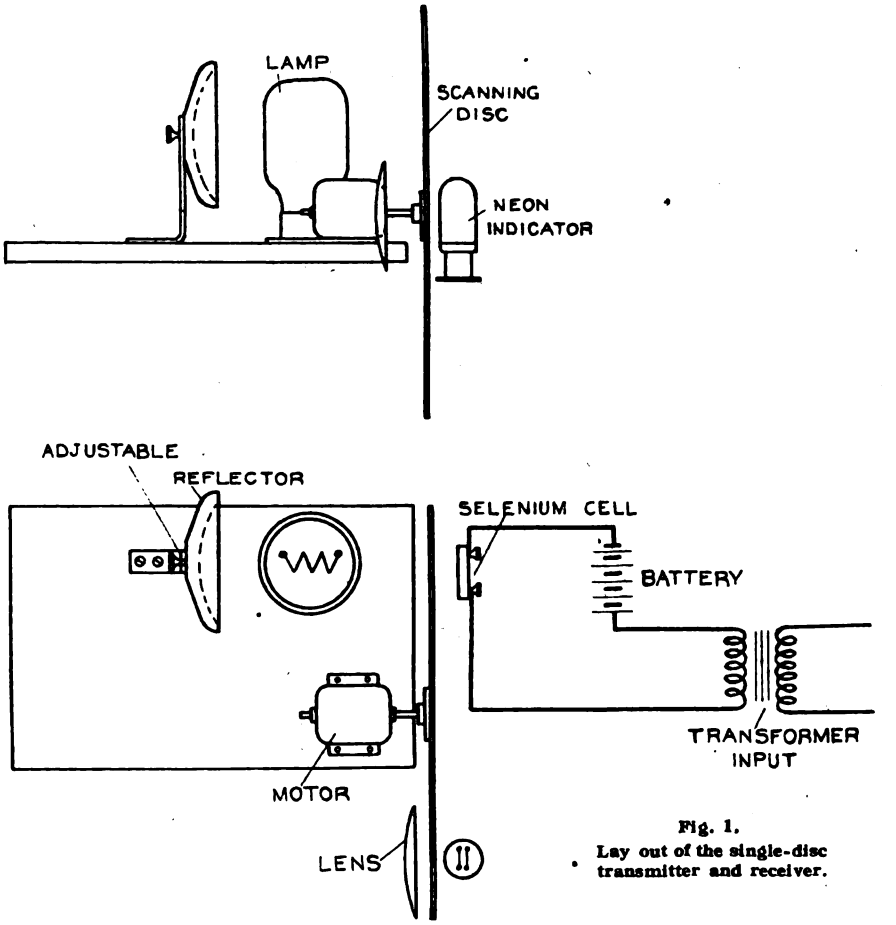

Fig. 1.
Lay out of the single-disc transmitter and receiver.

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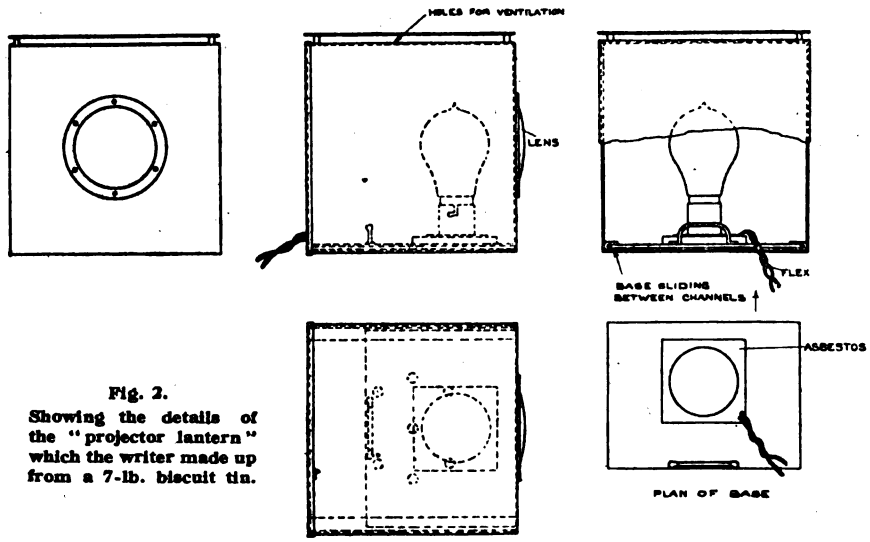

Fig. 2.
Showing the details of the "projector lantern" which the writer made up from a 7-lb. biscuit tin.

by ½ in. The diameter of the lens should not be less than 2½ in. The diameters shown in Fig. 2 were the actual ones employed when mounting the lens we used for our experiments. This lens, by the way, was purchased second-hand, and has a focal length of 6 in.

Mounting the Lens.

The next operation is the mounting of the lens. This is accomplished by using a metal ring cut from a piece of sheet tin. When cutting it out a pair of snips should be used to cut round the outer edge of the ring, and a series of small holes drilled round the circle marking its inner edge, as shown in the diagram. The centre can then be pushed out.

It will be noticed that the diameter of the inside of the ring is ½ in. smaller than that of the lens. We have, therefore, a ¼ in. overlap to hold the lens in position. Six 6-B.A. by ⅜ in. round-headed brass screws, with nuts and washers, are used to secure the ring to the main case of the lantern.

We must next turn our attention to the provision of suitable ventilation. It will be noticed that this is arranged for by the drilling of holes in the top of the case; the size of these is not important, and will, of course, depend upon the drills which the constructor has available.

Provision of Ventilation.

The top cover is made from the lid supplied with the biscuit tin. Cut the corners away at an angle of 45° and fold the flange under, thus making a strengthened and smooth edge. A 3/16 in. hole is drilled in each corner and corresponding holes made in the main case. Then, using four 2-B.A. by ¾ in. round-headed screws, 12 2-B.A. nuts, and four washers, the lid is mounted on the case; two nuts per corner should be used as distance pieces.

The base on which the lamp-holder is mounted is made from a piece of sheet tin of 20 S.W.G., a piece of fibre 4 in. × 4 in. × ¼ in., one standard batten-holder, and a tray handle. This latter can be obtained from an ironmonger or a "sixpenny stores." As will be seen, the construction of this lantern is quite a simple job and does not require fuller explanation if the diagram is carefully followed.

We have now to consider the type of lamp which is most suitable for general use in these experiments, and, as it is difficult to advise on this matter, I will describe the various types that have been used, mentioning the problems we have encountered, and leave the reader to choose for himself.

Best Type of Lamp.

Our first lamp was an ordinary 100-watt gas-filled bulb. It gave surprisingly good results when used in a horizontal position and we were naturally tempted to use a much brighter light. Accordingly, we replaced it with one of 500-watts, of a similar type. Trouble, however, was experienced with this bulb, arising from the size of the filament, which resulted in the reception of a patchy shadowgraph; this was due to the filament becoming focussed on the object that was being transmitted. Hence it was decided that a point of light was necessary. A standard carbon arc-light was therefore tried, but, owing to the flicker and to the need for constant adjustment of the carbons, it did not find great favour.

We then substituted for it a tungsten "Pointolite"—a rather expensive light source, as one requires also a resistance box, used in striking the arc.

A Simple Lantern.

The results obtained with this type of light were so much better that it was decided to try to improve the lantern itself, but, as experiments in this direction are not yet completed, I cannot refer to them in this article.

Before concluding my remarks on light sources I would like to describe a very simple lantern which was used in the course of our experiments. It was made from a circular tin about 4 in. in diameter, a batten holder being fixed to the bottom of the tin and a single concave lens mounted in the lid. See Fig. 3.

If one is lucky enough to find two circular tins which slide together they will form an excellent arrangement for focussing the light beam.

(*Continued on page* 318.)

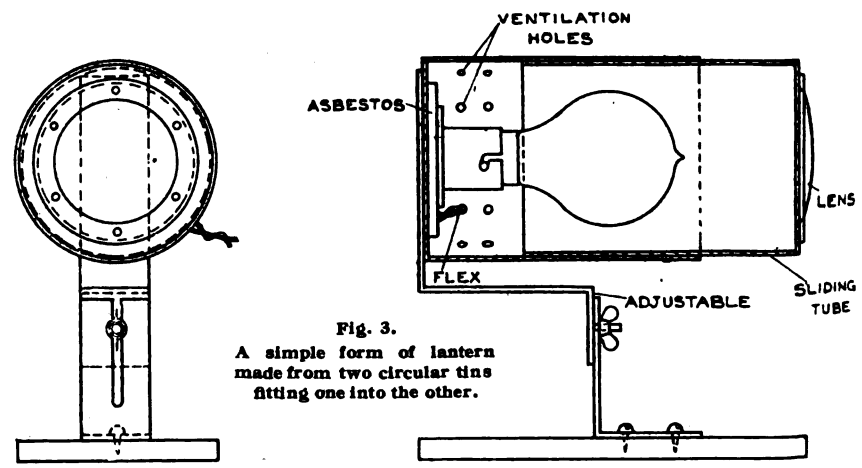

Fig. 3.
A simple form of lantern made from two circular tins fitting one into the other.

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The Detection of Small Quantities of Light

By E. E. FOURNIER d'ALBE, D.Sc., F.Inst.P.

THE electrical recording of small quantities of light is an essential problem of television and other arts. I shall here deal with methods of detection which have hitherto been found useful and indicate some lines along which further developments may be looked for.

Some Definitions.

Let us first agree on a terminology. The unit of light is the "international candle" based upon the 10 candle-power pentane standard. The unit illumination is called the "lux," and is the illumination produced upon a perfectly white surface placed vertically at a distance of one metre from a source of one candle-power. This illumination is independent of the extent of the surface, and must be carefully distinguished from the "flux" or amount of light. This is measured in "lumen," one lumen being the amount of light falling upon one square metre of surface from a source of one candle-power at a distance of one metre.

Having fixed upon a standard illumination and flux, we can subdivide the units in the usual way by using the prefixes "milli" and "micro" for one thousandth and one millionth respectively. We can even say "milli-micro" for a thousand-millionth, and thus arrive at very small units indeed.

Sensitivity of the Eye.

The eye is sensitive to an illumination as low as three milli-microlux, which is that due to a star of the sixth magnitude. The flux collected by the pupil of the eye is one-tenth of a micro-microlumen.

We may arrive at an idea of what energy this minute amount of light represents by studying actual sources of light. A Hefner lamp of one candle power sends out a radiant energy of 200,000 ergs per second in the form of visible light. The portion intercepted by 1 sq. c.m. at 1 m. is 1.6 ergs per second. The eye therefore

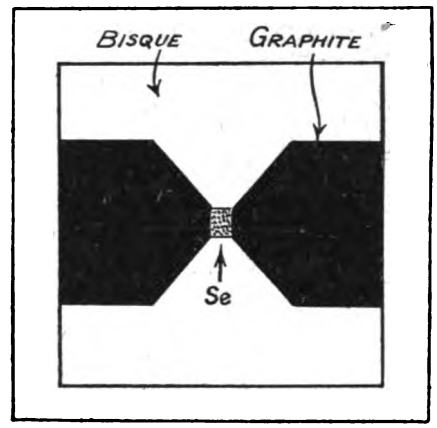

Fig. 1.
Special Selenium cell used for fringe counting.

intercepts 0.4 ergs per second at that distance, and 1.2 milli-micro-ergs at an illumination of 3 milli-microlux.

Nothing is here said about the colour of the light. If, for instance, the total radiation from the Hefner lamp were included, the amount of energy would be increased fourfold. Or, if all the light were, say, red, the energy would have to be greater to produce the same apparent luminosity, as the eye is less sensitive to red than to green.

The Problem of the Future.

It will be seen that the eye is a very sensitive instrument indeed for detecting small amounts of light. *The problem of the immediate future is to devise chemical and electrical means which will rival and surpass the human eye in efficiency.*

Let us see how far we have got. We have, in the main, three instruments at our disposal. These are the thermopile, the photo-electric cell, and selenium. In addition, we have the bolometer and the photographic plate. On account of its cumulative action, the last is very useful where slow phenomena are concerned. Stars several magnitudes beyond the limits of the eye can be recorded by the camera, which is thus the first instrument to reveal what was previously inaccessible to the human eye. The bolometer has been surpassed by modern forms of the thermopile, but even so the latter has got nowhere near the eye in visible radiations, although it is without a rival in the infra-red. Shinomiya's 0.06 erg per second, dating from 1919, remains hitherto unsurpassed.

Sensitivity of Photo Cells.

As regards the photo-electric cell, J. G. Kemp* claims to have discovered a candle at a distance of 4,300 m. by means of a photo-electric cell, which yielded a current of 10^{-14} ampere on exposure to the light from it. Such currents as these can only be discovered by the electrometer. Even so it was well within the competence of the eye, being equal to a star of about the third magnitude.

* *Physical Review* 2, 1, pp. 274–293, 1913.

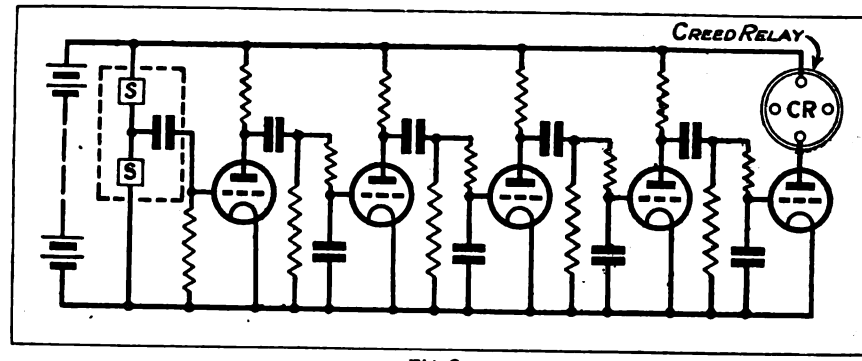

Fig. 2.
Symonds' fringe-counting device. SS = Selenium cells

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The General Electric Company has recently devised a condenser method for detecting these minute currents. A condenser is charged through a photo-electric cell and discharged as soon as a certain potential has been reached. The rate of discharge is the quicker, the brighter the light, and the discharge is marked by a click in a telephone. They claim that in this way lights of 0.001 lumen can be easily observed. But this is also well within the competence of the eye.

An Experiment still to be made.

Selenium has been followed down to 10 microlux (approximately the brightness of Venus, unaided) by means of a galvanometer. It then gave a current of the order of 10^{-9} ampere, which is very nearly the limit of sensitiveness of the galvanometer. With a sensitive electrometer currents can be observed which are 10,000 times smaller. As the instantaneous current through selenium varies in proportion with the illumination an instantaneous current should be yielded by an illumination of one milli-microlux, which is well beyond the sensitiveness of the eye. The experiment is still waiting to be done.

One of the finest achievements recently made in the utilisation of selenium is the work of Mr. E. O. Symonds in recording interference fringes. This was done by means of two balanced selenium preparations inserted in a battery circuit and connected to five valves in the manner shown in the diagram (Fig. 2). The fifth valve governed a Creed relay which registered the fringes by means of a syphon recorder. The fringes were obtained by steadily increasing the distance between the plates of a Fabry and Pérot interferometer made by Messrs. Adam Hilger. The illumination produced by a fringe was $\frac{1}{4}$ lux, and the amount of light utilised was of the order of one microlumen.

Counting Interference Fringes.

In spite of this feeble luminosity, the recorder worked steadily and uninterruptedly at the rate of about one fringe per second. At this rate a distance of half an inch was covered in about three hours. Anybody who has gone through the drudgery of counting thousands of interference fringes will know how much trouble is thus saved.

What makes the quest of the smallest discoverable quantity of light so exciting is the fact that, according to modern theory, there should be *a limit beyond which light cannot be divided*. For light of maximum visibility the quantum is 3.8 micro-micro-erg. Even when perceiving the minimum of light the eye receives some 300 quanta per second. In the course of its age-long evolution the human eye probably stopped short at a point where a continuous object would appear as a discontinuity.

Television Society

IMPORTANT NOTICE.

Programme of Lectures and Discussions arranged for the early part of next session :—

TUESDAY, October 1st.—H. S. Ryland, Esq. (Fellow, Optical Society), on "Talking Films" (with demonstration).

TUESDAY, November 5th.—F. Langford-Smith, Esq., B.Sc., B.Eng., on "Amplification and Television" (with experiments).

TUESDAY, December 3rd.—G. Priechenfried, Esq., on "Synchronising."

The programme of lectures and discussions for the remainder of the session up to May, 1930, is very nearly complete, and will be circulated to all members shortly.

Members of the Society will be interested to hear that the series of Informal Discussions, recently inaugurated, are to be continued throughout next session, provided that sufficient support is forthcoming from the members themselves, both in initiating and taking active part in these discussions. Members who have matters they wish to bring up are once again invited to write to the Lecture Secretary giving their suggestions in as concrete a form as possible. The discussions which have already taken place are printed in the last two issues of "The Proceedings of the Television Society," issued gratis to all Fellows of the Society. A limited number of copies of the printed discussions are obtainable, price 6d. each post free, from the office of the Society, 4, Duke Street, Adelphi, W.C. 2.

The Construction of Experimental Apparatus.

(*Concluded from page* 316.)

A suitable stand for the lamp is a job which can be left to the ingenuity of the constructor. However, in the diagram a suggested method is shown. The stand can be made from $\frac{3}{4}$ in. × $\frac{1}{8}$ in. soft-drawn brass, this particular metal bending easily.

My chief object in describing this type of lamp is to assist those of my readers who wish to experiment but have not the necessary mains supply. It will be found that a 6- or 12-volt bulb running from an accumulator will give a quite good beam of light.

In my next article I propose to describe the amplifier used in these experiments, giving full constructional details.

"Getting the most out of Radio."

The above is the title of an interesting catalogue which we have received from Messrs. Claude Lyons, Limited, 76, Old Hall Street, Liverpool.

The book contains an extensive and most interesting preface in which many useful hints and oddments of information of interest to wireless enthusiasts are given.

The remainder of the catalogue deals with a most interesting range of British and Foreign wireless receivers, components, "gadgets," and Precision Measuring instruments of various kinds. No experimenter should be without this handy book of reference.

Rubber as Shock Absorber.

From the Rubber Growers' Association we have received an interesting pamphlet entitled "Report upon the Relative Vibration-Absorptive Properties of certain Types of Rubber."

This report is reprinted from "The Bulletin of the Rubber Growers' Association," dated June, 1929.

The purpose of the investigation described in the report was to determine under various conditions the ability of rubber cushions placed beneath wireless receiving sets to isolate them from vibration. Various types of rubber were used and the report gives many interesting details as to the best types of rubber to employ under given conditions and the best methods of applying rubber cushions for any specific purpose.

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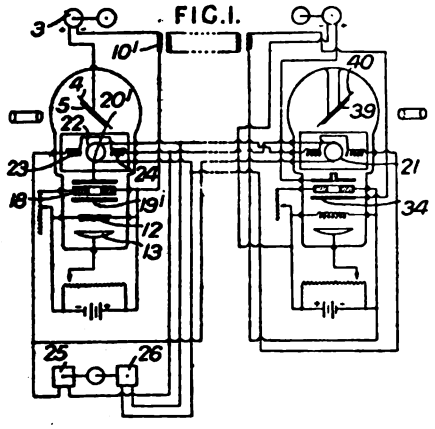
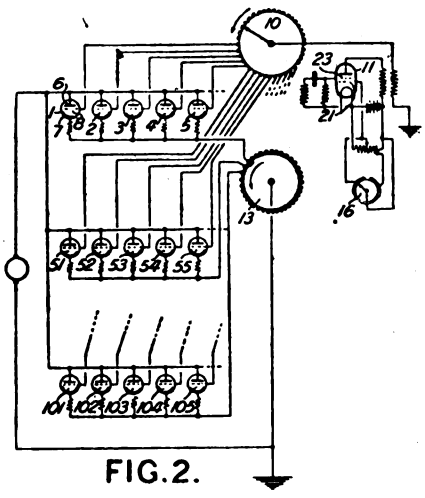
The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. each.



Protection is claimed in *Patent No.* 310424 (Convention date (Italy), April 25th, 1928) by R. Bruni for a system embracing the idea of utilising a weightless electron beam for exploring. Fig. 1 shows a screen (4) coated with selenium (5) or other light-sensitive material. This screen is illuminated by the projection on it of an *image* of the object to be transmitted, and at the same time is bombarded by a fine pencil of electrons. The source of electrons is a hot filament (12), the negatively charged reflector (13) serving to help concentrate these electrons into a narrow beam. This beam passes through narrow slits (19′) (20′) and a coil (18) fed with direct current, all of which help to concentrate the beam. It is claimed that the low-frequency coils (21) (22) and the high-frequency coils (23) (24) placed at right-angles to one another will cause the narrow pencil of electrons to explore the screen (4). Thus the whole of the screen will be explored in turn, and a modulated vision signal sent to line through the anode circuit comprising a direct current dynamo (3) and the transformer (10′).

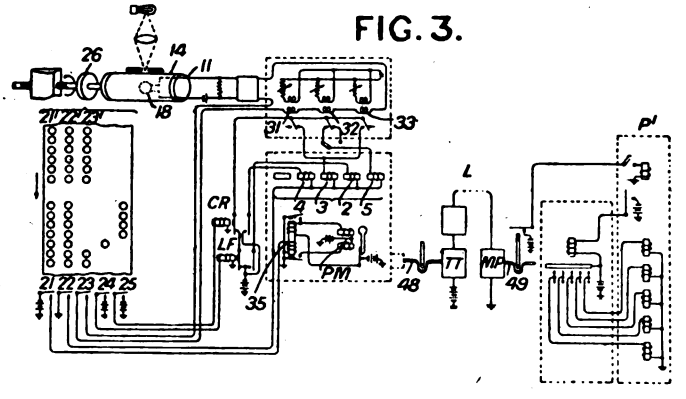
At the receiver the electron stream is controlled by applying the signals to a grid (34), and the anode (40) is coated with a fluorescent material (39). The coils for deflecting the electrons over the anode surface are energised by the same alternating current sources (25) (26) that energise the corresponding coils at the transmitter.

Patent No. 311075 (granted to Telefunken Ges. fur Drahtlose Telegraphie). In a television receiver comprising a bank of lamps (1) . . . (105), Fig. 2, which are activated synchronously with a transmitter, the glow lamps are brought to illumination by received signals and then each lamp, when once illuminated, is made to continue to glow, after the illumination signal has ceased and until extinguished by the reception of a further signal for that particular lamp. Each glow lamp comprises a cathode (7), an anode (6) to which bias can be applied from a source (23) insufficient in itself to cause illumination, but enough to maintain illumination when once started by a potential derived from the signals by an amplifier (11), and applied to an auxiliary electrode (8) through a synchronised distributor (10). The bias is applied in common to each row of lamps, and is removed from the rows in succession by a synchronised rotary circuit breaker (13). Half-tone effects are obtained by varying the frequency of illumination for different shades by periodically altering the sensitivity of the transmitter or receiver. For example, the grid bias applied to a space charge grid (21) in the amplifying thermionic valve (11) is periodically altered by a rotary switch (16). Alternatively the photo-electric cell at the transmitter is periodically optically screened.



A secret system of picture telegraphy is the subject-matter of *Patent No.* 311810 granted to W. E. Beatty and Bell Telephone Laboratories Inc., New York. In a copying telegraph a beam of light passes through a moving picture film (14) on to a light-sensitive cell (18), which controls electro-magnetic devices (31), (32), (33) in order to determine the punching of code combinations in a tape (48). The film is supported on a transparent drum (11) which is rotated and at the same time moved longitudinally relatively to the beam of light. The energisation of the electro-magnetic devices is periodically reduced or interrupted to restore them to the unactuated condition by connecting in circuit with them a contact (23), which is closed by studs (23′) on the drum (26) which is rotated with the drum (11). The electro-magnetic devices consist of marginal relays, which set up a combination in selector magnets (3) (5) which become effective by closure of their circuits at (22) by studs (22′).

(*Continued overleaf.*)



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THE BEST LETTERS OF THE MONTH

The Editor does not hold himself responsible for the opinions of his correspondents. Correspondence should be addressed to the Editor, TELEVISION, *26, Charing Cross Road, W.C. 2, and must be accompanied by the writer's name and address.*

BEACH COTT,
BOTLEY ROAD,
HEDGE END,
BOTLEY, HANTS.
July 7th, 1929.

THE EDITOR,
"TELEVISION."

DEAR SIR,

Re the article on "Atmospherics" on page 229 of this issue, it may be interesting to add that static "follows the sun," i.e. as the sun passes over and warms the air above the land, causing strong upward currents of warm air, static becomes prevalent in these localities and dies out in others. Thus, by judicious use of a frame aerial, turned in the direction *away* from the point from which the static is coming, it may be greatly minimised; viz., if static is being received from the west (our night), and the television or wireless transmitting station is north, by turning the frame north not only are strongest signals received from transmitter but static is cut out.

I am, Sir,
Yours faithfully,
W. H. HEBDIGE, Assoc. R.S.G.B.

"THE DINGLE,"
GROVE LANE,
HEADINGLEY, LEEDS.
July 14th, 1929.

THE EDITOR,
"TELEVISION."

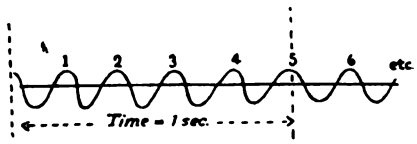
DEAR SIR,

I am sorry that Mr. Adcock still has difficulty in grasping the ideas put forward in my previous letters. May I therefore plead for more of your valuable space, in order to clear up, if possible, the misunderstandings which seem to have arisen?

Let us consider the equation $\lambda = \frac{c}{\nu}$

Here λ represents wavelength, ν represents frequency, and, most important of all, the term c stands for the *velocity of electro-magnetic radiation* (light) *under standard conditions*, i.e. through a medium of unit optical density. Such a medium we have in air, and the value of c is 3×10^{10} cm./sec. When we place this figure in the equation, *and at no other time*, the frequency corresponding to any wavelength, and *vice versa*, can be determined. Velocity of propagation has no effect on frequency or on wavelength considered apart. The term c has nothing whatever to do with the propagation velocity, but is a constant, imported as it were for the especial benefit and use of the equation connecting the wavelength and frequency of the radiation. As I remarked before, these two are correlated functions. If one increases, the other decreases.

This should be more readily grasped if one considers the diagram given herewith.



We are here representing some form of radiation, such that five complete waves are radiated in the space of one second. We can measure the wavelength corresponding to this frequency as the distance between successive crests. If now we double the frequency we get twice as many crests, in the same space, and the wavelength is thus halved. It is easy to see that we cannot have the same frequency corresponding to two different wavelengths.

The whole of the above may be summarised as follows. Corresponding to each wavelength λ there is a *definite* frequency of vibration, λ, i.e. the number of vibrations executed in unit time; these quantities are connected by the *fundamental relation* $c = \nu\lambda$, where c is the velocity (3×10^{10} cm. per sec.) with which light travels in free space.

I have not obtained this information from books, as Mr. Adcock infers, but I believe, if I remember rightly, that a discussion appears in "Preston's Theory of Light," though I have no copy of this by me.

With regard to the other point, according to Kingzett's "Chemical Encyclopædia," the coulomb is "delivered by one ampere flowing in one second," or, according to Hadley, the coulomb is the quantity conveyed *in one second* by a current of one ampere.

Should any of the above fail to convince your correspondent, might I suggest appealing to an arbitrator as the easiest way out of the difficulty.

Assuring Mr. Adcock of my earnest intentions to at all times assist him as far as is within my power, and again thanking you for your assistance in publishing these letters.

I am, Sir,
Yours faithfully,
H. WOLFSON.

NEW TELEVISION SCHEDULE.

With its new higher powered transmitter—5,000 watts—the Jenkins radio-movie transmitter W3XK, Washington, will send out its broadcasts for television fans on the band between 2,850 and 2,950 kilocycles or 101.6 to 105.2 meters. Transmissions will also be made on the band from 2,002 to 2,102 kilocycles, or 147.4 to 148.4 meters, for the benefit of those who are nearer by. It is probable also that by the time this is published nightly service instead of alternate nights will be available.

Invention and Development.

(*Concluded from page* 319.)

This is followed by the actuation of the punch magnet, *PM*, by the closing of the circuit of its relay winding (35), at contacts (21) by studs (21'). A transmitter, *TT*, sends code combinations of impulses over a line *L* in accordance with the punching in the tape, and a mechanical perforator, *MP*, at the receiver perforates a tape (49) which operates a printer *P'* to print an image of the picture.

Carriage return and line-feed combinations are punched in the tape (48) through selector magnets (2), (4) which are operated by contacts (24), (25) through relays *CR*, *LF*, and impulses produced in accordance with the punching control the carriage return and line-feed functions in the printer.

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SEP 10 1929

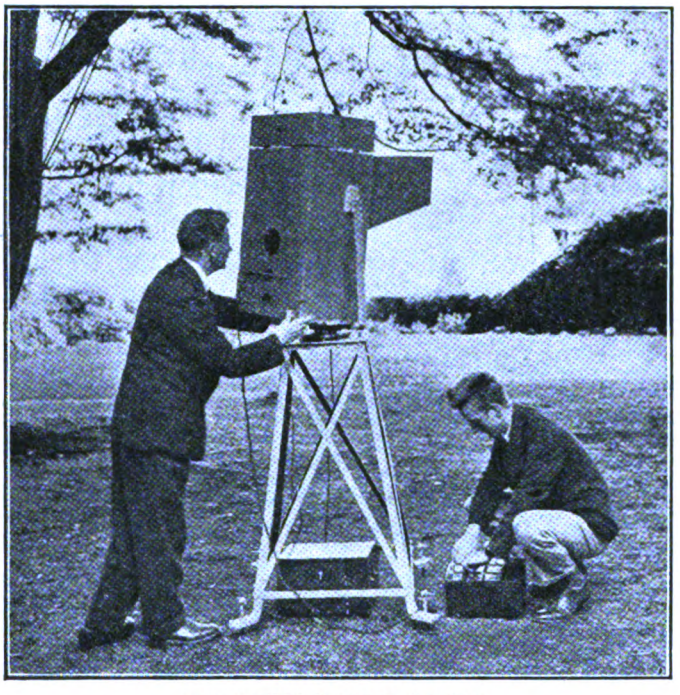
NOCTOVISION AND TELE-TALKIES

25¢ MONTHLY

Television

The Official Organ of the Television Society

VOL. 2 SEPT. 1929 No. 19



AN "EYE" FOR SHIPS.

Photograph of the Noctovisor which was recently demonstrated to the Press on Boxhill, Surrey. By means of this instrument ships in fog can see the distant lights of approaching vessels. See article on page 337.

THE WORLDS FIRST TELEVISION JOURNAL

THE TELEVISION SOCIETY

The Television Society was founded on September 7th, 1927.

The Society makes its appeal to those who desire to share in the responsibility of furthering this new branch of applied science.

THE OBJECTS OF THE SOCIETY

may be summarised as follows:

(*a*) The Study of Television and its application in applied science and industry.

(*b*) To afford a common meeting ground for professional and other workers interested in current research relating to Television and allied subjects and to afford facilities for the publication of reports and matters of interest to Members.

(*c*) To encourage the formation of *Local Centres* of the Society in the Provinces, so that by social intercourse and discussion among members these aims may be more fully realised.

The present register indicates a world-wide membership.

ORGANISATION.

The Society consists of one Honorary Fellow, Fellows and Associates, and the management is vested in a Council of Fellows, including the President, three Vice-Presidents, and Ordinary Fellows.

FELLOWS.—Ordinary Fellows must be elected by the Council. Candidates for the Fellowship must be proposed by two Ordinary Fellows, the first proposer certifying his personal knowledge of the candidate.

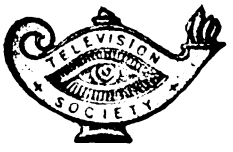
ASSOCIATES.—Any person over 21 interested in Television may be eligible for the Associateship without technical qualifications, but must give some evidence of interest in the subject as shall satisfy the Committee.

STUDENT MEMBERS.—The Council have arranged for the entrance of persons under the age of 21 as Student Members.

SUBSCRIPTIONS.—The annual subscription for Ordinary Fellows is 20s., with an entrance fee of 10s. 6d.; and for Associates 10s., with an entrance fee of 5s.
The annual subscription for Student Members is 5s., entrance fee 2s. 6d.

LIFE MEMBERS.—Life Membership may be secured at a fee of £10 10s.

MEETINGS.—The ordinary meetings of the Society are held in London at the Engineers' Club, Coventry Street, W.1, at 8 p.m., on the first Tuesday of the month (October to May inclusive). Notices of meetings are posted to all members about seven days before the meeting.



Full-size reproduction of the new Television Society Badge, which is available to accredited Members, and may be obtained from the Head Office, price 1s.

The official organ of the Society is "Television," published monthly by the Television Press, Ltd., 26, Charing Cross Road, W.C.2.

A memorandum for the guidance of members wishing to form a Local Centre of the Society may be obtained (gratis) on application to the Joint Hon. Secretaries, 4, Duke Street, Adelphi, W.C. 2.

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Television

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Vol. II SEPT., 1929 No. 19

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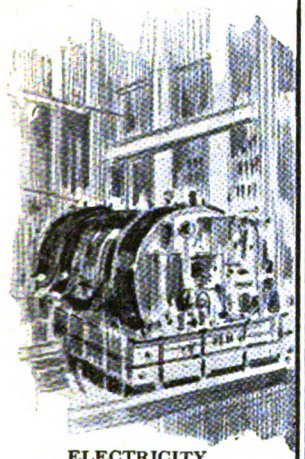
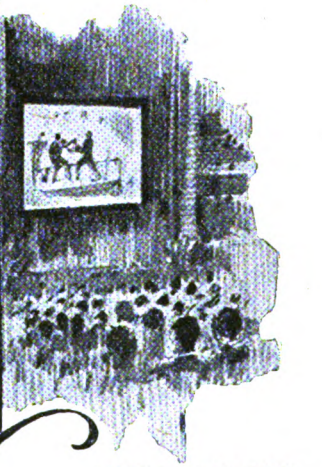


ELECTRICITY

MECHANICS

CHEMISTRY

OPTICS



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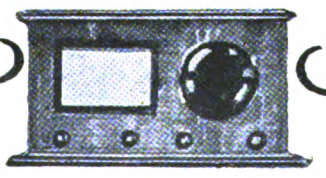

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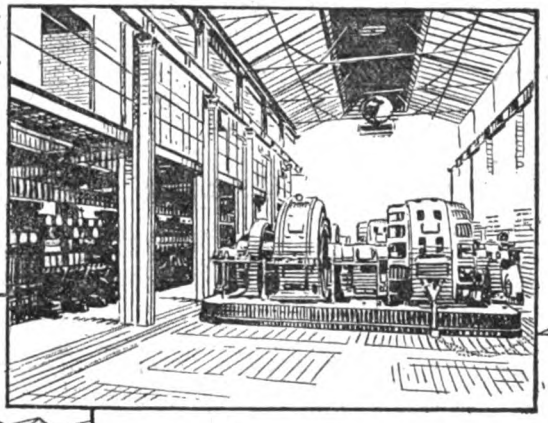

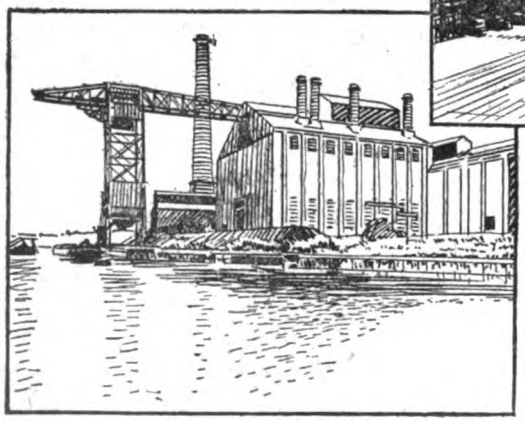

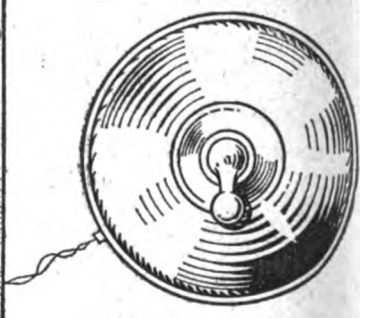

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Television

THE WORLD'S FIRST TELEVISION JOURNAL

The Official Organ of The Television Society

Edited by A. DINSDALE, A.M.I.R.E.

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Technical Editor: J. C. RENNIE, B.Sc., A.M.I.E.E.

Vol. II] SEPTEMBER 1929 [No. 19

EDITORIAL

WHEN the problem of television was first solved by Baird in 1926 he established a leadership in this field of endeavour which he has maintained ever since. As reported elsewhere in this issue, he has again asserted that leadership by his recent public demonstrations of the Noctovisor and "Tele-Talkies."

* * *

OUR readers will remember that Noctovision was first demonstrated before members of the British Association at Leeds in September, 1927. In essence, it consisted of a system of television in which invisible infra-red rays were used to "illuminate" the sitter instead of ordinary visible light, so that the sitter appeared to be sitting in total darkness. At the time this invention was simply a scientific curiosity. Now Baird has commercialised the principles involved, and produced a machine which will undoubtedly prove invaluable to ships at sea by enabling them, while in fog, to see the lights of approaching vessels.

* * *

"Tele-Talkies."

SEVERAL foreign workers have recently been engaged upon experiments in the transmission by television methods of cinematograph films. It is not generally known that Baird made successful experiments along these lines some years ago, but abandoned them in order to perfect television proper. Now he has produced a machine capable of transmitting not only ordinary silent films, but talking films as well. He has christened the process Tele-Talkies. A special transmitter is necessary, of course, but the standard Baird televisor receiver will receive either television or tele-talkies without modification.

* * *

As to applications for this development, there are several uses to which it could be put. Ordinary sound broadcasting programmes are occasionally helped out with gramophone records. We may expect that television broadcasting programmes will also be helped out on occasion by the transmission of a talking film, thus enabling possessors of television receivers

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to see and hear a talking film in their own homes.

* * *

TOPICAL films cannot at present be transported physically over great distances because of the loss of time involved, which renders the film, on arrival, no longer topical. Transmission of the film by television methods would eliminate time loss, and enable audiences in any part of the world to see a topical film within a few hours of the actual event. These and other applications of Baird's latest development will undoubtedly be perfected in the not far distant future.

* * *

In this Issue.

IT is with considerable satisfaction that we go to press with this issue of TELEVISION, for it contains a goodly measure of what we feel sure our readers will agree are important contributions.

* * *

SIR Ambrose Fleming, drawing on his vast fund of mature experience, sets forth an ingenious analogy which shows up the present attitude of the B.B.C. in its true perspective, and thereby proves the utter futility of its attempts to frustrate the development of television. He cites the cases of several other great inventions which interested parties have tried to crush in the past, and points out that no really great new invention can be suppressed which provides something which the public wants. Official or other discouragement will simply drive the invention abroad, to give employment and satisfaction to the inhabitants of another land Later, we have to buy (instead of being able to sell) the finally developed product of the invention.

* * *

IN another part of this issue there appears an arresting and prophetic article by Mr. Shaw Desmond, who, like Sir Ambrose Fleming, is too well known to our readers to require any introduction. Mr. Desmond visualises a time when the intensive spread and development of television and other methods of instantaneous communication will make time, as we know it and measure it, look ridiculous. The city of the future, he says, will be roofed in with flexible glass; artificial suns will abolish night; men will work throughout the twenty-four hours in eight-hour shifts; and by means of atomic energy, heat from the tropics will be pumped to the Polar regions, while cool air will be pumped back into the tropics, thus enabling future generations to manufacture their own climate.

* * *

A TERRIFYING outlook, perhaps. But, as all those know who have read his book, "Ragnarok," Mr. Desmond has an uncanny knack of predicting things which, although they appear fantastic at the time, ultimately become possible of achievement.

* * *

OF great value to students of television is Mr. J. H. Owen Harries' article on "The Literature of Television." Much of this literature is scattered about in the form of articles, papers, and discussions. For the first time an attempt has been made to list the more important works in a form such that reference can readily be made. He also describes a simple and extremely useful method of compiling references so that any required article can be quickly traced. In this connection it is interesting to note that the Television Society has been engaged for some months on the task of compiling an index to television literature, which it is intended to make as complete as possible. This index, when ready, will be available to members.

* * *

Television in Germany.

NOW that Fernseh A.G. (the Baird Company's German partner) has been formed, things appear to be moving rapidly in the German television world. One important piece of news which has just come to hand is that the German Government has adopted as standard the 30-hole scanning disc used by Baird. Incidentally, this report reveals for the first time how many holes the Baird Company has been using, and answers the vast number of readers who have written to ask us about it.

* * *

IT is perhaps characteristic of German efficiency that, thus early in the development of television, the Government has stepped in and standardised the scanning disc. Obviously, endless confusion would soon reign if different manufacturers were allowed to make apparatus, each employing his own special number of holes in the scanning disc. This confusion has already arisen in America.

* * *

There promises to be a good display of television apparatus at the annual radio exhibition, to be held in Berlin between August 30th and September 7th. So that we may be able to give our readers a comprehensive account of the situation in Germany, the writer has arranged to attend the Berlin exhibition himself. A report of his visit will appear in our October issue.

* * *

The Radio Exhibition.

FOLLOWING the German radio exhibition, our own annual show will take place at Olympia between September 23rd and October 3rd. Readers who visit the exhibition will find "Television" at Stand No. 241. A new feature of the arrangements this year is a specially erected grand staircase to the balcony, immediately facing the main entrance to the New Hall. As you ascend this staircase you will find Stand No. 241 immediately on your left at the top. You can't miss it. Readers are invited to pay us a visit and are assured of a hearty welcome.

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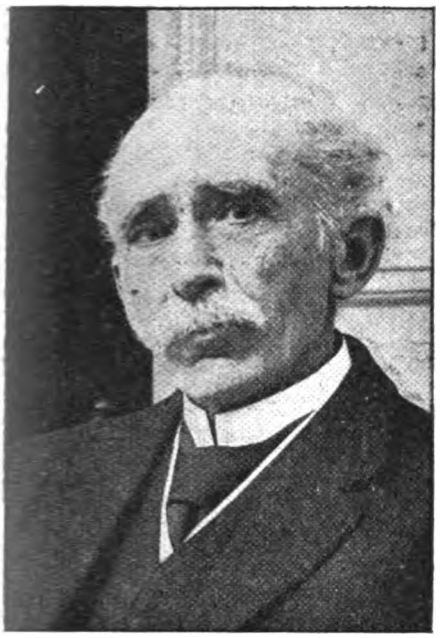

SIR AMBROSE FLEMING.

The B.B.C. and Television

By Sir AMBROSE FLEMING, F.R.S.

During the course of a long and active career our eminent contributor has witnessed the birth of many great inventions, such as incandescent electric lighting, the telephone, and wireless telegraphy. In the following article he briefly describes how attempts were made by governments and/or vested interests to obstruct development of these inventions, and how Great Britain in many cases was the loser thereby. He shows up clearly the short-sighted and futile policy which has recently been adopted towards television by the B.B.C.

"No obstruction," writes Sir Ambrose, "can stop the progress of an invention if it provides for a real demand by really new means."

I CANNOT help thinking that the attitude of the B.B.C. towards television is to a large extent determined by their anticipation of that to which they may be committed if they afford any assistance to its development.

Let me illustrate my meaning by a simple parable.

Suppose that the greater proportion of our population were blind, or at any rate, so short-sighted they could not see more than a few inches in front of them. The result would be that all places of entertainment would appeal only to the sense of hearing.

"Music Halls for the Blind."

Theatres or music halls need have no scenery and actors and actresses no "make up" or wardrobes because no one could see them. Plays would be performed on bare stages by actors in ordinary day dress, and a blind audience would get what pleasure it could from hearing the talking or singing, but seeing nothing.

Let us then suppose some troublesome inventor devised a kind of spectacles or opera glass which would enable this purblind audience to see to some extent, even if in its initial form it could only take in one actor or actress at a time.

The result would be to create a demand for something to "see" as well as "hear." But we can readily imagine that the management of these music halls and theatres for the blind would not look favourably on this new invention. They would say to themselves: "If we encourage this new fad of 'seeing' and give opportunity for improving the appliances for it then we shall be forced to provide something to 'see,' and that will mean scenery and other expense, and wardrobes and 'make up' for our theatrical performers."

Hence, their natural tendency would be to frown upon it, call it a useless and impractical device, and give no opportunity, except perhaps 10 minutes in the middle of the night occasionally, for its exploitations.

But all experience shows that when a new line of invention has been opened by the discovery of some genuine principle or fact its improvement is only a matter of time and money; and the latter can call in any amount of inventive power to improve and augment.

It was so in the case of incandescent electric lighting, the telephone, wireless telegraphy, and even broadcasting itself.

No obstruction can stop the progress of an invention if it provides for a real demand by really new means.

In the early days of electric lighting gas engineers assured everyone that no electric lamp could possibly displace gas as an illuminant.

In the early days of the telephone official telegraphists called it a toy, and at the first achievements of Marconi in effecting wireless telegraphy across the English Channel, even eminent scientific men declared it to be useless for any serious purpose.

We all know how these prognostications have been falsified by history.

There is one thing that official obstruction can do, and that is to place Great Britain at the tail instead of at the head of the procession and force us ultimately to have to buy from other nations that which we ought to have been in a position to sell to them.

As an example of this, take the case of telephone line loading. Forty years ago an eminent British scientist, the late Mr. Oliver Heaviside, pointed out the improvements which would accrue from giving inductance to telephone lines. The government electricians of that day had some crude theories of their own about telephone lines and turned a deaf ear to Mr. Heaviside's arguments.

Then, later on, when Pupin in America had proved the practical importance of "loading" telephone lines with inductance coils, and when Krarup in Denmark had tried uniform loading and demonstrated

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its efficacy," loaded " telephone lines in America and Germany were laid down. Ultimately in Great Britain the post office engineers had to adopt the improvement, and we had to buy from the United States quantities of " loading coils " as the result of neglecting to foster Heaviside's ideas.

The overwhelmingly important fact is that we in Great Britain do not produce food enough in this country to feed our population for one-fifth of the year. Meat and wheat for all else have to be bought from other countries ; we can only buy this food by giving in exchange raw materials such as coal, iron, tin, etc., which we dig from our soil or else by giving manufactured articles which we make.

The only true remedy for unemployment is, then, to encourage and stimulate by every possible means new manufactures or foster existing ones. We cannot cure unemployment by doles or artificial and temporary expedients like road-making. But **every new practical technical invention is a basis for fresh employment.**

Hence it is the most disastrous thing to allow official short-sightedness or prejudice to hinder a fair trial being given to any new invention which may afford a basis for novel manufactures. **The public themselves are the final court of appeal to decide whether a new appliance is useful or not, or meets a requirement.** If they do not want it or get tired of it soon then there is nothing more to be said. But **no official body has a right to anticipate that judgment and prevent a good and fair test being made,** sufficient to enable the public fairly to decide whether they want the new thing or not.

To return, then, to my parable.

The British Broadcasting Corporation are in the position of the management of an enormous music hall for the blind. All who pay 10s. a year to the G.P.O. and buy a wireless receiver can enter this hall and hear all that is going on, *but they can see nothing.*

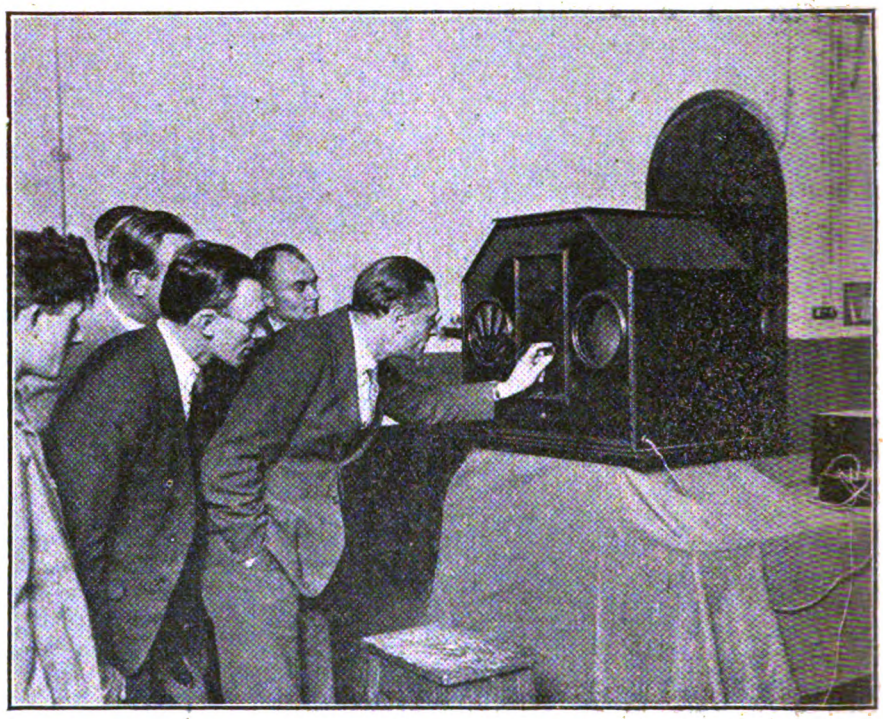
Then along comes a troublesome inventor, Mr. Baird, and shows the management a kind of opera glass which will enable the members of this blind audience to see the performers, at first perhaps only one at a time.

Handsome Announcers Wanted.

But the management say : " We have always done our best to amuse and instruct our audiences by ear and we do not want to encourage them to ask to 'see' as well. Suppose we did do it. Why, then we might have to equip television studios one day so that our singers and lecturers might be seen as well as heard, and all that would mean out-lay and more elaboration ! Moreover, the performers might not like it, and it would lead to the same kind of difficulty as in the 'talkie' pictures. There, formerly, ability to act and good looks were the sole requirements. Now a good voice is required as well. We might then have to meet a demand for handsome announcers and pretty singers possessed of good looks in addition to good broadcasting voices ! "

Probably something of this kind is floating vaguely through the minds of the B.B.C. management and inducing in them a counter electromotive force opposing the introduction of television into their programmes

Some persons may object to the analogy and say it is not correct because, in ordinary vision, the person who is seen merely has to be exposed to a general flood of light of sufficient intensity, whereas in television, so far as yet invented, he has to be regularly traversed by a spot of light and the mechanism which does this has to be synchronised with the mechanism of the receiving apparatus. This, however, may not always be the case. It may be possible by a large lens or mirror to form a brilliant image of a stage scene, and it will be this image and not the persons of the actors which will be " scanned " by the transmitter. This has not yet been perfectly done.



Television in South Africa.

In connection with the meeting of the British Association in South Africa this year demonstrations of the Baird system of television are being given. This photograph shows a party of South Africans looking in to the first television demonstration ever given in the Union. See account on another page of this issue.

Nevertheless, the problem of television is sufficiently attractive to bring to its solution many minds ; and the great United States Telephone and Telegraph and Radio Corporations have enormous resources for experimental research at their command, and they will throw themselves into it if they think there is any public demand for its solution.

The question then is : **Shall Great Britain be left behind ?**

Is it to be the old story of the aniline dyes again repeated ? Is an initial and fundamental invention

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made in Great Britain to be left for other more progressive countries to exploit and obtain the benefit of?

Twenty-eight years ago I wrote an article for *The Nineteenth Century and After* Review in which I pointed out the disadvantages under which I thought Great Britain had laboured by the purchase of the telegraphs by the State in 1870, and the drafting of the Telegraph Acts of 1868 and 1869 in such form as to give the State an absolute control over every form of electro-communication.

The chief objection is that the official mind is very slow in taking in new ideas and very reluctant to take risks or launch out on new departures. Hence, nationalisation acts as a brake on inventive progress because no inventor can obtain a proper trial of his invention unless he can break through the adamantine wall of official prejudice or lethargy. The only power which will do this is Public Opinion.

Write to the B.B.C.

The obvious course, then, is to stimulate those who desire to see a new experimental appliance given a fair test to write to the B.B.C. management and impress on them that a full and fair opportunity must be given to this new art to see what it can do in practice. What is required is an opportunity for test at a reasonable time of the day or evening, and for a not-too-short period of time.

It is not likely that people will purchase television receivers unless there is a fair prospect of being able to receive something. The only result of blocking the way for the development of television in Great Britain will be to foster it elsewhere, and no one can say at present what the ultimate result of such a policy would be. We had plenty of examples at the beginning of the Great War, in 1914, to discourage it.

But busy people have short memories and it may have been all forgotten.

Someone once said that it requires a surgical operation to make a Scotchman see a joke; which is certainly not true, but it seems as if something of the kind is required to make any public utility corporation, which has settled itself down to a certain line of work, deviate from it and break new ground.

Propaganda

WHEN the steam engine was forecast people laughed, and they have continued to laugh as each new progressive step in science has been made. The only time they did not laugh was when Darwin told them there was much of the ape in their constitution. Then they got angry.

Novelties of all kinds are funny, because they are incongruous. They do not fit in with our scheme of the universe. Anything which would really upset the universe would be awful, using the word in its true sense. We should fear it. Therefore, these novelties must be treated as jokes, so as to preserve the unities.

Those of us who honestly believe that the day is not far off when even the resistance of the B.B.C. will be broken down, and television will be as much an everyday affair as gramophones are now, must not get impatient with this laughter. It would be better to welcome it, and rejoice that the prospect has not aroused the much greater opposition, fear. (Of course, that may be the trouble at Savoy Hill.)

Still it is not of laughter that I would write, or of fear, but rather of propaganda. Television is a highly technical thing. Only the few can appreciate its inner mysteries and its complex mathematics, and just in virtue of this fact it attracts, as its keenest adherents, a type of man who is somewhat intolerant in his outlook.

The technician has a mind that revels in difficulties. There is no joy to him in the car that goes and goes. He is happy when oil drips down his neck, and grease exudes through his shirt, and the devil in the engine eludes him. A technical friend of mine, home for a holiday, leaves workshops and motor engines a hundred miles away—so he comes round and offers to take my car to pieces, just for the sheer joy of the task. To my reply that it is going nicely, and needs no attention, he merely answers by snorting.

I imagine that the large majority of the members of the Television Society, and readers of this magazine, are such technical fiends. They may not be all of the constructive type, but the technical side has attracted them primarily. Overcoming technical difficulties of one sort and another is their hobby, and that such things do not make a universal appeal is to them one of the unsolved mysteries of life.

The fact remains, however, that this small majority, the salt of the earth if you like, are a minority, and that progress in this world is the result of the co-operation of majorities. You have to create a demand before you can sell a supply. That even applies to food, as witness the thousands spent on advertising it.

The moral of this point of view is that those who are mainly interested in the technical side of television owe something more than mere enjoyment to their hobby. They should be missionaries, because there is more in television than wires and circuits and neon lamps, more than higher mathematics and spinning electrons. There is the cultural value that a definite service would have upon mankind, a cultural value far higher than that of sound broadcasts.

I suggest that every reader of TELEVISION sets out at once to proselytize at least one personal friend, and rouse sufficient interest in him or her—it is sometimes easier to tackle the opposite sex—to make the convert take a practical interest in the subject. The best of all interests is that he helps to create a public demand for trial, at least. Once there is the demand then the money will be forthcoming for the many experiments needed to improve existing standards.

Let us have a slogan—**One more reader of "Television," one more member of the Society before 1930.** It is an individual slogan for each one of us. See what you can do.

W. F. F. S.

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First Television Demonstration in South Africa.

In our July issue we announced that Lord Angus Kennedy, Vice-President of the Television Society, accompanied by two engineers, had left for South Africa to demonstrate the Baird system of tclevision before members of the British Association, whose annual meeting is being held this year at Cape Town and Johannesburg. On going to press with our August issue we received a cable from Lord Angus announcing his arrival at Cape Town, and the setting up of his apparatus in Cape Town University. We give below the latest information from Cape Town.

(The following account is taken from *The South African Wireless Weekly* of July 24th, 1929.)

"The very first demonstration of television took place on Monday afternoon when Lord Angus Kennedy demonstrated the Baird television outfit that he has brought out to South Africa to about a dozen members of the press and broadcasting authorities.

"A great deal is to be said for the speed in which the apparatus was assembled, for it must be remembered that the gear did not arrive here until Thursday last, and what is more, certain parts of it arrived in a damaged condition, therefore credit must go out to the two officials accompanying Lord Kennedy for being able to give even a small demonstration four days after its arrival.

"When referring to the demonstration as small, I am using Lord Kennedy's own words, for a demonstration proper of four or five people singing and playing the piano, etc., is to be given later in the week and I shall have more to say of this in next week's issue.

"From the point of view, however, of proving that television is an accomplished fact, the demonstration was a huge success, for one and all present were agreed on the point that television as demonstrated was far ahead of what we had been led to believe, and such remarks as "wonderful" and "marvellous" were very prevalent.

"The head and shoulders of one of the officials who was seated away in another room in front of the transmitter, appeared perfectly clearly on the receiving screen. Every little detail was evident even to the smoke arising from the pipe being smoked by the person being televised. The speech via the loud speaker, which is an integral part of the television receiver, was also excellent and it was rather uncanny to see for the first time lips moving and the actual speech coming from a loud speaker.

"Altogether it must be admitted that the demonstration was highly successful and it merely leaves one with eager anticipation of a more complete demonstration with several figures and instruments being utilised."

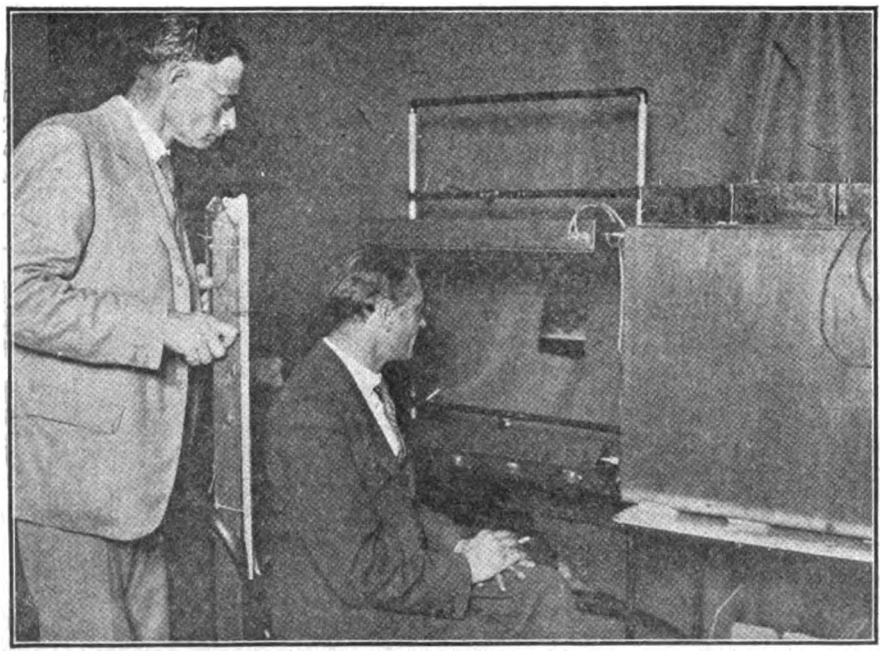
* * *

Great Enthusiasm.

Lord Angus Kennedy, in a special despatch to TELEVISION (from Cape Town) informs us that there is a great deal of enthusiasm for television among wireless amateurs, and the Radio Society is considering the possibilities of forming a group centre of the Television Society in Cape Town.

A large number of distinguished people visited the extemporised television studio in Cape Town, headed by the Governor General of South Africa, The Earl of Athlone, Princess Alice, and Lady May Cambridge. The Mayor and Town Councellors of Cape Town also attended a demonstration. One of the Councillors wrote in the visitor's book: "Came here a sceptic; went away a believer."

Every possible facility is being placed at his disposal at the University at Johannesburg, and the South African Postmaster-General, together with the South African Broadcasting Company, have agreed to the use of the Johannesburg broadcasting station for experimental television transmissions.



This photograph, just received from Cape Town, shows Lord Angus Kennedy (left) arranging a sitter before the television transmitter in the extemporised studio in Cape Town University.

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SOME CONSIDERATIONS OF AERIAL SYSTEMS FOR RECEPTION

By R. L. SMITH-ROSE, D.Sc., Ph.D., A.M.I.E.E.

ALL radio receivers are designed to bring about the satisfactory operation of the terminal piece of apparatus, whether this is the telephones or loud-speaker, or the optical equipment of a television receiver. This operation entails the supply to the apparatus of a minimum electromotive force which is delivered to it from the last of the amplifying or rectifying stages of the receiver. In general, the output given by the receiver bears a fixed relation to the electromotive force supplied to it from the aerial system.

Now the electromotive force induced in the aerial is proportional to the strength of the electric waves sent out from the transmitting station at the place of reception, and also to the effective height of the aerial. Since under normal conditions one has no control over the strength of field created by the transmitting station, it is always desirable to ascertain that the design and arrangement of the receiving aerial is carried out in the most efficient manner that the prevailing conditions permit. It will therefore be interesting to consider briefly the effect of certain conditions upon the current induced in receiving aerials by the passage of wireless waves from a distant transmitting station.

Interchangeability.

In the first place we may turn to a brief consideration of the conditions which make for an efficient transmitting aerial; for it is well known that in wireless, as in all other subjects involving wave radiation, the source and receiver are generally interchangeable in their main properties; in other words, an efficient transmitting aerial will generally make a good receiving aerial.

From the earliest days of the construction of high-power wireless transmitting stations the problem of the relative advantages of wooden and steel masts for aerial supports has been debated by wireless engineers. The possibilities of a reduction in the effective height of the aerial, and of loss of energy by eddy currents in the masts, have been investigated theoretically, and in some cases attempts have been made to carry out measurements with a view to obtaining more definite information upon the point.

"ALL radio receivers are designed to bring about the satisfactory operation of the terminal piece of apparatus, whether this is the telephones or loud speaker, or the optical equipment of a television receiver. In general, the output given by the receiver bears a fixed relation to the electromotive force supplied to it from the aerial system."

From the above it is apparent that one of the most important parts of a radio receiver is the aerial, some points in connection with which are discussed by Dr. Smith-Rose in this article.

The general result of experience up to a few years ago in the construction of the comparatively long-wave transmitting aerials was that from a wireless efficiency point of view there was not much to choose between the different types of mast available. The accessibility of the site and the cost of material more often governed the choice.

The steel mast was favoured by many engineers on account of its greater strength, although it is to be recalled that for many years the wooden masts of the San Paolo station at Rome, 714 feet high, were among the highest in the world. In a few cases steel masts have been set up and insulated from earth, notably at Hanover, where a steel mast, 825 feet high, was supported on a glass ball-and-socket arrangement, and insulated with a similar joint at a height of 495 feet. In this way it was presumably hoped to combine the advantages of the steel and wooden masts in so far as the latter formed a support for the aerial insulated from earth.

Insulated Steel Masts.

The most notable example of such construction is the Post Office high-power station at Rugby, where all the masts, 820 feet in height, are insulated from earth on a porcelain and granite block construction. Arrangements were provided so that the masts could either be connected to earth or left insulated, and some special tests were made in which the radiation from the station was measured in the two conditions. These tests showed that the effective height of the aerial with the masts insulated was 1·22 times the effective height with the masts earthed. Although the resistance of the aerial was somewhat greater in the former case, it still required some 20 per cent. more power in the aerial to produce the same radiation with the earthed as with the insulated mast system.

The shielding action of a steel mast on an aerial which it supports is due to the field created by the currents induced in the mast by the external electromagnetic field. The mast, in fact, behaves in the manner of a vertical aerial, untuned and directly connected to earth.

In Fig. 1 is represented a vertical aerial placed in the path of arriving wireless waves, which in the ordinary way have their electric force E_1 practically vertical. This force induces an electromotive force in the aerial exactly in phase with it, and as a result a current flows up the aerial. This current causes an electric charge to build up at the top of the

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aerial, with the result that a secondary electric field, E_2, is produced around the aerial. At points near the earth it is evident that this secondary electric field is vertical and is thus parallel and opposite to the primary electric field of the arriving waves. It is thus obvious that if the phases of the two fields can be made similar a reduction of the electric field of the arriving waves will take place around the base of the aerial.

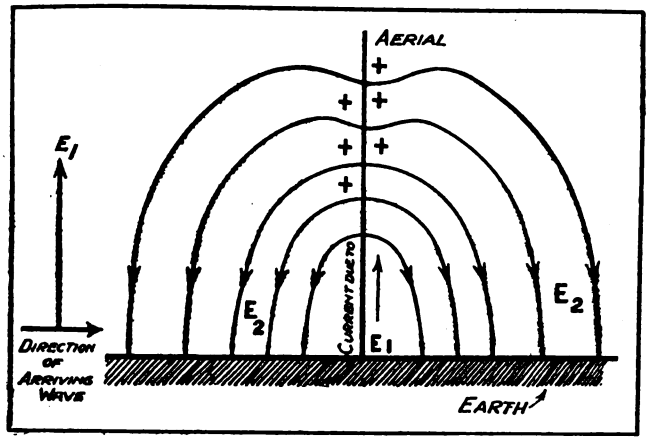

Fig. 1.

The arriving waves with an electric field E_1, induce a current in an untuned vertical aerial, which produces a secondary electric field E_2. Near the foot of the aerial E_1 practically neutralises E_1, and so the arriving waves cannot be detected on a receiver in this position.

Phase Relationship.

A consideration of the case outlined above shows that the correct phase relationship is brought about when the natural wave-length of the aerial is much less than that of the arriving waves. For aerials of height up to 100 feet or so, and wave-lengths from 250 to 600 metres, this condition is fulfilled by simply connecting the aerial to earth untuned. In this condition, of course, the current flowing may be very small, and it is to be expected that only a small reduction of field will be produced in the neighbourhood of a single wire aerial. It is further to be pointed out that near the upper half of the aerial the direction of the secondary electric field is materially different from that of the primary field, and thus the reduction in strength of the latter may be small in this region.

In the case of receiving aerials, these facts may be simply demonstrated by arranging two aerials in the manner shown in Fig. 2. With aerials of 20 to 40 feet in height set at about 3 to 4 feet apart it will be found that the signals from, say, 2LO received on one of the wires will be unaffected by the earthing or tuning of the other wire. When the distance between the wires is decreased to less than one foot the earthing of one wire produces a definite decrease in the signal intensity received on the other wire. As the height of the screening wire is increased relative to that of the receiving aerial, the screening effect becomes more and more marked. The reduction in signal strength is also considerably greater when a cage of several screening wires is employed.

For example, in one experiment on this subject a vertical aerial 40 feet high was erected inside a cage formed of vertical wires fixed at the top and bottom to the sides of a wooden frame five feet square, erected round the aerial. Both the aerial and cage were supported by pulley arrangements, so that either could be raised or lowered at will. With the cage formed of four wires only, and hauled up so that it projected about two feet above the top of the aerial, the screening effect was almost negligible. When the aerial was lowered to 30 feet the earthing of the screen produced a noticeable drop in the signal strength received on the aerial, showing that the screen was beginning to be effective. When the aerial was lowered so that it was only a quarter of the height of the screen, the effect of the latter was very marked when connected to earth in the untuned condition. When the screen was tuned the signal strength obtained on the aerial increased to practically its normal unscreened value.

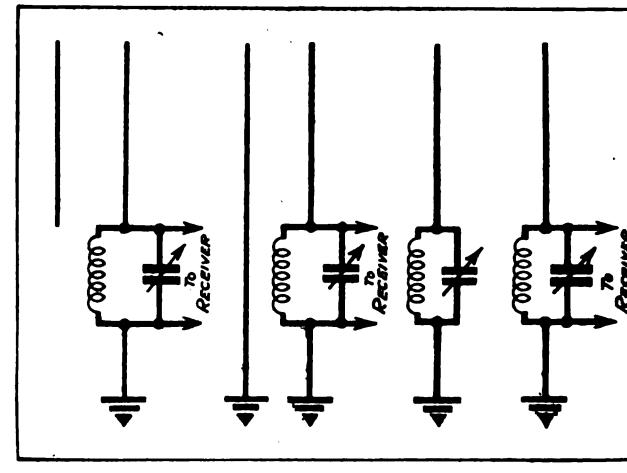

Fig. 2.

Arrangement of two vertical aerials to illustrate mutual screening effects in the insulated, earthed, untuned and tuned conditions.

Effect of Enlarged Screen.

At this stage of the experiments the screen was enlarged to 32 equally spaced vertical wires along the sides of the five feet square frame. In this condition the screen was very effective and, when connected to earth in the untuned condition, rendered it very difficult to receive any audible signals on the enclosed vertical aerial.

From these experiments, and the theoretical reasoning given above, it will be understood that a large steel mast can effectively screen a relatively small aerial placed near it, provided that the wave-length employed is materially greater than the natural wave-length of the mast.

These deductions have been confirmed by the results of some quantitative experiments carried out in Germany, in which it was shown that the electric field from the local broadcasting station was reduced to 10 per cent. of its normal value at a distance of two or three feet from the base of a lamp-post some twenty-five feet in height. The measurements also showed that the screening effect of the lamp-post was detectable on the ground at a distance from the base approximately equal to its height.

It will now be interesting to discuss

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the manner in which the principles outlined above apply to the typical receiving aerial slung between some convenient point near the top of a house and a mast at the far end of

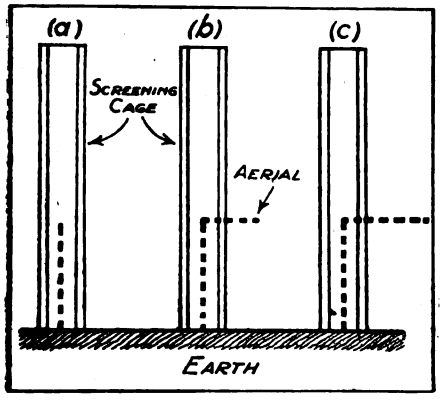

Fig. 3.

Experimental apparatus to determine the effect of a vertical wire screen on inverted L aerials of equal height and varying horizontal length.

the garden. In such circumstances the gas and water pipe systems and the electric light wiring of the house can be regarded as untuned earthed conductors, having a height comparable with that of the aerial and a natural wave-length well below that for which the aerial is normally used.

Effects of Buildings.

It will be gathered from what has already been stated that, provided the aerial is kept at a distance of three or four feet away from the walls of the house, the existence of such conductors will produce little or no effect upon the strength of the received signals. Where the house is one of a number in a row, having similar metallic systems, the combined screening effect may, however, become very appreciable.

Alternatively, if the height of the screen is several times the height of the aerial, as may easily be the case in a block of flats or mansions, the reduction of signal strength received on a vertical aerial may become very marked indeed; since a vertical untuned aerial reduces the incoming-field strength to a small fraction of its original value at points close to its base where it is connected to earth. Many readers may think that this is contrary to their general experience, and the explanation of this difference lies in the fact that most receiving aerials have a horizontal portion which is at least as long as the vertical portion, and that under such conditions the screening of the aerial by the metal work in buildings is materially reduced.

The state of affairs which prevails when an attempt is made to shield an inverted L-type aerial by a vertical screen may be understood by referring to Fig. 3, which illustrates a further experiment carried out with the wire cage already mentioned. A straight vertical aerial, about 15 feet high, was erected inside the vertical cage, 40 feet high, as depicted in Fig. 3 (*a*). When so arranged the aerial was found to be completely screened for all practical purposes. A horizontal portion was now added to the aerial in successive stages, as shown in Fig. 3 (*b*) and (*c*), and a test was made of the signal strength received on the aerial.

Action of Horizontal Part.

It was found that, even with a length of only 10 feet protruding, the effective screening action was considerably reduced, and that it diminished steadily as each successive stage was added. In general, it was found that the screening of the vertical lead was only effective when the horizontal length was less than the height of the screening cage.

To understand the action of the horizontal part of the aerial it is necessary to consider in a little more detail the secondary field set up by the currents in the vertical screen, as depicted in Fig. 4. A study of this diagram will show that at the base of the aerial the secondary field E_2 is vertical, and is opposing the primary field E_1, due to the arriving waves. At points halfway up the screen, however, the secondary field has an appreciable horizontal component, and this component will induce an electromotive force in the horizontal portion of the aerial, increasing with its length and in the same direction as that which would be caused by the primary wave field in the vertical portion of the aerial.

It thus appears that for practical radio reception purposes there is no need to take excessive precautions to try and prevent the vertical down lead of an aerial from being screened, provided that there is a sufficient horizontal portion attached to the top of the aerial. In the same way, the down lead of such an aerial would not be appreciably screened by the presence of a metallic supporting mast, or the metal wire stays of a mast.

Carelessness not Advocated.

It must be understood that we are not advocating that experimenters be careless in the arrangement of their aerials. What may be very serious in the above cases is the shunt capacity effect of neighbouring objects in diverting the aerial current away from the receiving instrument.

Another point of importance, also, is that serious eddy current and dioelectric losses may be introduced into the aerial circuit if the down lead is close to other objects, whether earthed or not. Both of these disadvantages can be overcome, however, by allowing as great a spacing as possible between the aerial lead and the surrounding objects. Otherwise the aerial should be as high as possible and have as much top horizontal portion as the location permits.

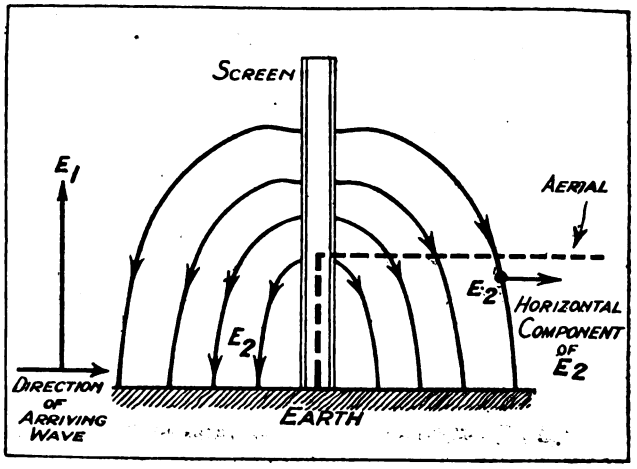

Fig. 4.

Currents induced in the screen wires produce a secondary field E_2. The horizontal components of this field induce in the horizontal portion of the inverted L aerial or electromotive force which assists that induced by the field E_1, in the vertical portion of the aerial.

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The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

PART IX.—FROM COHERER TO VALVE

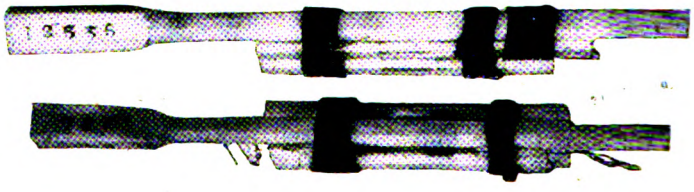
IN the last article we saw how, on the 12th of December, 1901, Marconi signalled across the Atlantic for the first time by receiving in Newfoundland a series of the letter "S," sent from Poldhu in Cornwall. This marked the close of the purely experimental period, and there was now no doubt that wireless telegraphy would prove to be an important addition to existing means of communication, not only with ships, but between different parts of the world.

Magnetic Detectors.

Up to the time of bridging the Atlantic, the receivers used had consisted of some form of coherer, but in the following year, 1902, Marconi patented his Magnetic Detector which, though it was not suitable for producing the message on a tape, was much more sensitive than any of the coherer types of receiver. With the Magnetic Detector the message was read by buzzing sounds in the Morse Code in a telephone receiver.

Telephone reception held the field for many years, and is still used extensively, especially for signalling with ships. Within the last few years, however, machine telegraphy, which was dealt with in a previous article, has been widely adopted for high speed wireless signalling between land stations. The messages are received on a tape, either printed or in the Morse code, instead of by sound in a telephone; indeed, the normal speed of signalling is far too great to be read by ear.

Several forms of Magnetic Detector were invented about this time, but Marconi's type was the only one which came into commercial use extensively. In Marconi's detector, a band of iron wires is drawn by clockwork through a magnetic field. The band moves through a glass tube on which is wound a coil of wire with one end connected to the aerial and the other to "earth." Over this coil there is a bobbin wound with wire, the ends of which are connected to the telephone receivers. The moving band distorts the field, and the received currents have the effect of reducing this distortion. These changes in the magnetic field produce currents in the bobbin of wire connected to the telephones and so produce buzzing sounds in the latter. It is a very robust instrument, and, except for winding up the clockwork, no adjustment is required. This detector was used successfully for many years in ships and stations fitted with the Marconi Company's apparatus.



Some early sensitive tube receivers, supported on bone, ready for mounting in the coherer receiver.

Electrolytic Detectors.

Other companies in the United States, France and Germany made much use of Electrolytic Detectors, which, like the Magnetic, were used in conjunction with telephones. A common type consisted of two dissimilar metals, one a metal point and the other a large surface, immersed in an acid solution. When at rest, a non-conducting film formed on the point, causing the circuit through the liquid from one metal to the other to have a high resistance. The received oscillatory currents from the aerial disturbed this film, which reduced the resistance, and so allowed currents from a cell to flow through the detector, and produce sounds in the telephone receivers.

These Electrolytic Detectors at their best were more sensitive than the Magnetic type, but had the disadvantage of being more delicate and less easy to adjust.

Crystal Detectors.

These two types of detector, the Magnetic and Electrolytic, held the field until the advent of Crystal

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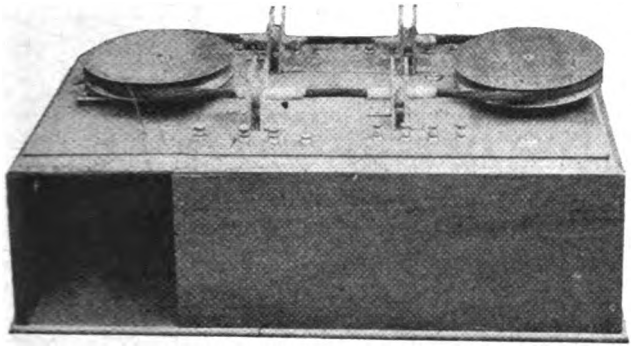
Detectors, which are probably familiar to all readers of this journal. These detectors were first used in America, by Dunwoody and Pickard in 1906, and they are still used in many broadcast receivers and ship installations.

A Crystal Detector consists of a crystalline material in contact with a metal or another crystalline material, the efficiency of the combination as a detector depending on the materials used. These detectors offer a low resistance to a current in one direction across the contact, and a high resistance to a current in the opposite direction. The alternating currents produced in the receiving circuit can thus be converted into unidirectional pulses of current which are suitable for working a telephone. They are said to act as "rectifiers" to the alternating current.



An early model of the Marconi Magnetic Detector on which is mounted four primaries and secondaries using the same moving iron band.

Fleming's Valve.

But even before the advent of the Crystals their ultimate supremacy was doomed by the epoch-making invention of John Ambrose Fleming of England, who is now the President of our Television Society, and whose outstanding work in radio communication was publicly acknowledged this year by the conferring on him of a knighthood by H.M. the King.

In the early eighties of last century, Edison in America, and Fleming in England, noticed that when electric lamps burned out, the glass bulbs became blackened; and both of them investigated this phenomenon. It was not, however, until 1904 that Fleming patented the Oscillation Valve, the action of which was based on the results of those old researches of twenty years before. This was the two electrode valve, one electrode being the filament of the lamp, the other a metal cylinder inside the bulb. The space between the hot carbon filament and the metal cylinder possesses unilateral conductivity so that, like the Crystal Detector, the Valve can be used as a rectifier, and applied to the reception of wireless signals. It is now in extensive use as a rectifier of alternating current for various purposes. As a wireless detector it was not quite so sensitive as the best crystal type, but it was more stable, and, what was far more important, it initiated a completely new line of investigation for the reception of wireless signals.

The Audion.

The first great advance along this new line, which Fleming had opened up, was made in 1907, by Lee de Forest of America, who introduced a third electrode in the form of a perforated metal plate or "grid." There were thus three electrodes; the lighting filament, the plate introduced by Fleming, and the grid introduced by de Forest. When a telephone receiver was joined in series with a battery across the filament and the plate, and when the grid was connected to the receiving circuit so that the electric oscillations produced by the signals caused variations of electrical pressure on the grid, then the space between the filament and plate became conductive, and currents from the battery, flowing across this space, produced sounds in the telephones.

This three-electrode valve, which could be used not only as a detector but also as an amplifier, that is to say, as a means of magnifying the strength of signals, was called by de Forest the Audion.

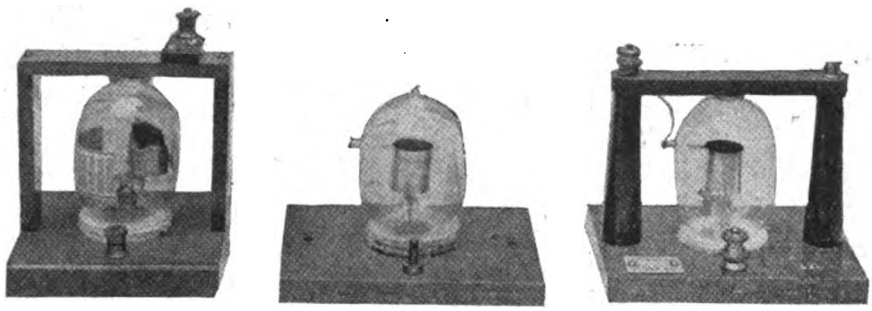
It is now generally agreed that de Forest's introduction of the third electrode into Fleming's Valve was the most important step in the whole history of wireless signalling, but, in saying that, let us not forget that it was laid down by the Courts in America that this introduction was merely a modification of Fleming's master patent.

The Valve has been aptly called "the modern Aladdin's lamp." Not only has it revolutionised wireless telegraphy, but it has made possible wireless telephony, line telephony over vast distances, wired wireless, talking films, facsimile transmission, synthetic music, television, and noctovision. Even this list is not complete, but it is complete enough to show what we owe to the foundations laid by Sir Ambrose Fleming of England, and Dr. Lee de Forest of America.

Spark Gaps.

Having thus briefly summarised the development of receivers, it may be of interest to have a look at what was happening on the transmitting side.

When Marconi first signalled across the Atlantic in December, 1901, he used a fixed spark gap and glass plate condensers, which were charged by alternating current through transformers. In smaller installations he was using an induction coil for charging the condensers which were made up of Leyden jars. There were few important developments for the next five years apart from alterations to circuit arrangements, arising from the tuning patents of Marconi and Lodge, which were mentioned in the last article. Then came new forms of spark gap.



Some of the original models of the Fleming two-electrode valve.

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The first type of spark gap, which consisted of two fixed metal balls, was succeeded by rotary gaps of various designs. By the use of these gaps, the rate of sparking and the duration of the sparks could be controlled, an arrangement which improved transmission, and also improved the note of the signals in the receiving telephones. Many spark installations in ships are still equipped with gaps of this type; others employ a type which was first used by Max Wien in Germany in 1906. This latter type, called the quenched gap, consists of a number of very small gaps in series, the electrodes consisting of metal discs with large sparking surfaces, as opposed to the small surfaces of the rotary type.

The Arc.

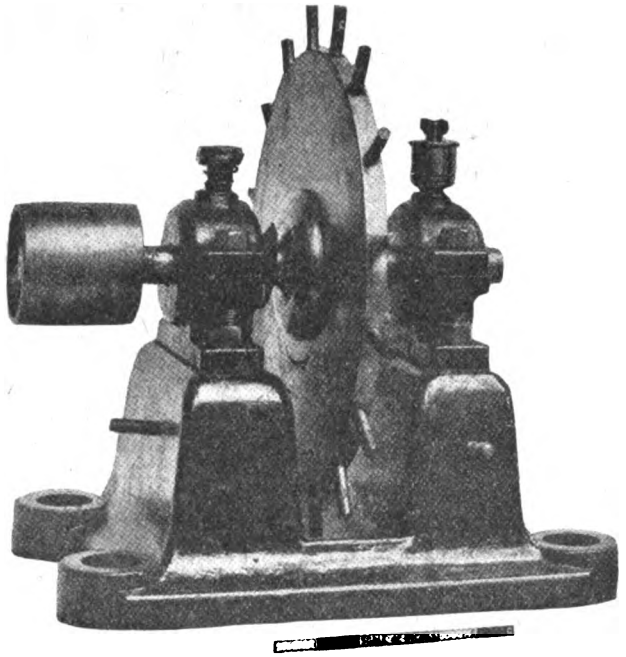
In this same year, 1906, Valdemar Poulsen of Denmark, demonstrated in London a new system of generating wireless waves, based on a discovery made six years before by William Duddell of England. Poulsen's patent, which was taken out in 1903, consisted essentially of using an electric arc in alcohol vapour or hydrogen, in place of a spark. He showed that with this arrangement the radiated waves were much more persistent than with the spark system, and to Poulsen, indeed, must be attributed the invention of the first practical system of continuous wave signalling.

It was adopted slowly, almost grudgingly, in Europe, but quickly received support in the United States, where it was used extensively at many high power stations. Later, during and just after the war, it was similarly adopted for many large installations in Europe, and indeed, is still used at a number of stations, but for all practical purposes it may be said that the introduction of high power Valve transmission sounded the death-knell of the Arc.

The Marconi Company, instead of using an Arc, developed a rotary spark, called the Timed Spark System. It was claimed to be a continuous wave system, but it was not used apart from the Company's own stations.

The Alternator.

A more serious competitor to the Arc, however, was the High Frequency Alternator, which is still used at many high power stations throughout the world. Dr. R. Goldschmidt of Germany was the first to produce a practical high power transmitter of this type in 1911. He was quickly followed by several others with various types of Alternators. Foremost amongst these inventors were Alexanderson of America, and Bethenod and Latour of France. With these alternators, the high frequency current is produced in the aerial without the necessity of having the large condensers and transformers which were required in the old Spark installations. The Marconi Company installed Alexanderson Alternators at their high power station at Carnarvon, but, with that exception, no use was made of the system in this country.



An early example of a rotating disc discharger for spark transmitters.

The transmitting position during the war, and for the next few years, was that high power stations were all being equipped with Arcs or Alternators, but the majority of low power stations were still keeping to the Spark. In ships, the Spark system remained supreme, though in America a few ships were fitted with Arc installations.

Wireless Telephony.

This is the time when wireless telephony began to emerge from its prolonged chrysalis state. With the damped waves of spark transmission, telephony was quite out of the question as a practical proposition, though it was always in the experimental background. Everyone knew that as soon as continuous wave transmission was invented, wireless telephony was bound to follow, but it was several years after Poulsen's Arc patent of 1903 before much success was attained; in fact, wireless telephony was hardly more than a plaything until de Forest added the third electrode to Fleming's valve in 1907.

Experimental work had, of course, been going on continuously with both Arcs and Alternators, and in November, 1906, R. A. Fessenden of America, using an Alternator, actually sent telephone messages across the Atlantic. He was carrying out tests in America, and some of the messages were heard at his station at Machrihanish in Scotland.

Telephony Delayed.

Neither the Arc nor the Alternator, however, was really suitable for telephony, at any rate not nearly so suitable as the Valve, but even after the Transmitting Valve came in, it took several years before telephony became a practical proposition. Just as war was breaking out, seven years after de Forest's patent, telephony was coming to its own. The war gave a great impetus to wireless telegraphy, which was a going concern and was suitable for coded messages, but it delayed the development of telephony, which was neither one nor the other. Experiments did of course proceed, especially in neutral countries and in America; and immediately the war was over, wireless telephony at last came to its own, to rank with aviation as one of the two outstanding inventions of the first quarter of the twentieth century.

(The author is indebted to Marconi Wireless Telegraph Co. Ltd., for the illustrations in this article.)

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HOW NEON IS OBTAINED

By W. F. F. SHEARCROFT, B.Sc., A.I.C.
(Fellow of the Television Society)

As at present developed, one of the most important parts of a television receiver is the neon tube which constitutes the necessary light source. Neon is one of the rare gases about which little is known even by those who are keenly interested in television. In the following article Mr. Shearcroft describes the history of the discovery of neon, and how it is obtained. In another article in this issue the practical details of the manufacture of neon tubes are described.

WHEN Chemistry firstclimbed out of the morass of Magic, and ceased to search for the Philosopher's stone, it turned serious attention to the question of the chemistry of burning things. This, as we can appreciate today, led to an understanding of the atmosphere.

A century and a half of experiment culminated in the famous theory of Lavoisier, in which combustion was explained as the chemical union of the burning substance with oxygen of the air. It was established that this oxygen constituted one-fifth of the air by volume, the residue being called nitrogen.

It is an extraordinary fact that that simple statement summed up the constitution of the atmosphere, until the end of last century. It was recognised, of course, that the atmosphere contained varying amounts of water vapour and a small proportion of carbon dioxide derived from combustion, decay and the living processes of animals; but the air, purified of these substances, was oxygen and nitrogen only.

Cavendish's Discovery.

Both of these substances were studied closely, and their properties measured and catalogued without any discrepancies being noted. This, despite the fact that the Hon. Henry Cavendish pointed the way very clearly to the advances which were made a century later.

Cavendish noted that not very much was known about nitrogen or *phlogisticated air* as he called it, and set out to made further investigations upon it. He describes an oft-quoted experiment in these words, where modern names are substituted for those in use in his day:

"I, therefore, made an experiment to determine whether the whole of a given proportion of nitrogen of the atmosphere could be reduced to nitrous acid, or whether there was not a part of a different nature from the rest, which would refuse to undergo that change."

For this experiment he sparked a mixture of oxygen and nitrogen over water, and thus caused them to combine, producing nitrogen oxide fumes which were absorbed by the water. He found that, after continued sparking, there was a residue, and he cautiously concluded that, "as some remained unabsorbed, it did not appear for certain whether that was of the same nature as the rest or not."

An Important Conclusion.

Cavendish varied his experiments, and finally found that a small bubble of gas was left, after these sparking experiments, about 1/120 of the volume of the nitrogen with which he started. His final conclusion was that "if there is any part of the nitrogen of our atmosphere which differs from the rest . . . we may safely conclude, that it is not more than 1/120th of the whole." At that he was content to leave the matter.

This most important conclusion attracted no attention, and no further progress was made until Lord Rayleigh in 1892 carried out a number of determinations of the densities of various gases of which nitrogen is one. Now, nitrogen can be obtained from some of its compounds, and it can also be obtained from the air as a residue left when the other known components have been absorbed. Rayleigh examined samples from both sources. With the utmost care he determined the weights of equal volumes from different sources, with results such as the following:

	Weight of equal volumes. gm.
I. Nitrogen from Nitric oxide	2·30008
,, ,, Nitrous oxide	2·29904
,, ,, Ammonium nitrite ..	2·29869
,, ,, ,,	2·29870
,, ,, Urea ..	2·2985
II. Nitrogen from air (i) ..	2·31026
,, ,, ,, (ii) ..	2·31003
,, ,, ,, (iii) ..	2·31020
Average of Series I ..	2·29927 gm.
,, ,, ,, II ..	2·31016 ,,
Difference ..	0·01089 gm.

These weighings were made with a known error of not more than 0.0002 gm., and so the discrepancy could not be attributed to experimental error.

It was big enough to claim earnest attention, and to suggest that atmospheric nitrogen and nitrogen obtained from its compounds were not identical. In collaboration with Sir William Ramsay (then Prof. Ramsay) a detailed examination of atmospheric nitrogen was undertaken.

Discovery of Argon.

Some air was carefully dried, freed from carbon dioxide, and passed backwards and forwards over red hot copper until all the oxygen was absorbed. A similar process with the residue over heated magnesium resulted in the formation of magnesium nitride, and the disappearance of all but a tiny bubble of gas. Cavendish's sparking experiment was also repeated, and his results confirmed. The minute quantity of gas obtained in this way was further purified, and found to have a molecular weight of 40.

Further investigation showed that it would not enter into chemical union with any other element, which suggested the name ARGON from the Greek word for *lazy*. It was

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further decided that this gas was a new element, and that its atomic weight was also 40, the molecule being supposed to consist of one atom only.

Ramsay and Travers carried out a further series of researches with this gas. Starting with about 18 litres of argon obtained from the atmosphere, they liquified this by cooling in a Dewar tube, and obtained a few cubic centimetres of a clear liquid. This liquid they allowed to boil slowly, and collected the gas evolved in fractions. The first fraction was a gas with a density of 14·7, but on cooling this gas by liquid air, part liquified and a residue was left having a density, after further purification, of 10·1.

Neon Established.

This gas was established as another new element, and called NEON (Greek=new.) We must leave the further investigation, which resulted in the isolution of other elements from the crude argon obtained from the air. We know now that this crude argon is a mixture of gases, all of which are now considered to be elements, and are grouped in a class alone in the periodic table, and called the INERT GASES or THE RARE GASES OF THE ATMOSPHERE.

It was thought at first that they might be just polymers of nitrogen—that is, more-or-less condensation products; but in view of the fact that they exhibit characteristic spectra, that they have a general family likeness in their chemical inertness, and exhibit the usual gradation of properties we expect in a family of elements, it is generally agreed to consider them as elements.

The inert gases occur in the atmosphere in the proportions shown in the following table:

Percentage of Inert Gases in Air.

	By volume.	By weight.
Argon ..	0·932	1·285
Neon ..	0·0015	0·001
Helium ..	0·0005	0·00007
Krypton ..	0·000005	0·000014
Xenon ..	0·0000006	0·0000025

They are colourless gases without smell, and the gradation of some of their properties is seen in the table below:

Table of Properties of Inert Gases[1]

	Helium.	Neon.	Argon.	Krypton.	Xenon.	Niton.
Symbol	He	Ne	Ar	Kr	Xe	Ni
Atomic Number ..	2	10	18	36	54	86
Ratio of specific heats..	1·652	1·642	1·65	1·689	1·666	—
Weight of 1 litre ..	0·1786	0·9002	1·7818	3·708	5·851	9·97
Density (o=16) ..	1·998	10·100	19·95	41·506	65·35	111·5
Molecular Weight (=Atomic weight) ..	4.00	20·20	39·88	82·92	130·2	222·4
Critical temperature in ° absolute	5°	60°	150°·6	210°·5	298°·6	377°·5
Critical Pressure in atmospheres ..	2·75	29	47·9	54·3	58·2	62·5
Boiling point in ° absolute	4°·5	27°·1	86°	122°	163°·9	211°
Melting point in ° absolute	—	—	83°·4	104°	133°	202°

[1] Modified from *Text Book of Inorganic Chem.*, Vol. I., Frund.

From crude argon they may be obtained by several processes. They may be separated by differential diffusion, a troublesome method. Fractional distillation of the liquid, crude-argon we have already mentioned. Another method is to treat the mixture of gases with freshly prepared coconut charcoal at low temperature. The heavier gases are absorbed more readily, and a mixture of helium and neon is left. This is then treated with fresh charcoal at a lower temperature still, and the neon is absorbed. After pumping the helium away, the neon can be liberated when the temperature is allowed to rise.

Method of Obtaining Rare Gases.

The most favoured method starts with the gas, mainly nitrogen, which escapes from air-liquifiers. This is liquified, air is blown through it, and fractionally distilled. The first fraction contains all the helium and neon. After removal of any oxygen and nitrogen, the neon can be obtained by the method mentioned above.

Helium, argon and neon have found practical uses. Helium, being the lightest known substance other than hydrogen, provides an admirable substance for filling balloons, as it is not inflammable. Argon is largly used for filling gas-filled electric light bulbs. Neon owes its practical use to the peculiarity it exhibits of giving a bright light when subjected to electric discharges and neon-filled tubes are familiar to all of us, with their ruddy glow, in advertisement signs.

The neon tube also functions prominently in television as the transformer of electrical impulses into light impulses. It occurs in the atmosphere in the proportion of 1 volume in 55,000, and has been observed as a component of the gases contained in numerous natural mineral springs. These may prove to be the best source in time. It is stated that the Bourbon-Lancy spring provides 547,500 litres of gas per year, of which 16,644 are rare gases

Neon Difficult to Obtain.

Neon is the most difficult of the rare gases to obtain, but for the purposes for which it is required, very small quantities suffice. It is stated to have two isotopic forms, and it has been claimed to have been produced by the action of electric discharges on hydrogen at very low pressures; but the claim has been disputed.

Its density is 0·9002 gm.±0·0003 gm., which corresponds to a calculated molecular weight of 20·20. Like all the rest of the family, it is considered to be monatomic, and so its atomic weight is also 20·20 (Oxygen=16).

As a gas it more nearly approaches "perfection" than hydrogen. It exhibits a strange property of giving a red glow when shaken with mercury.

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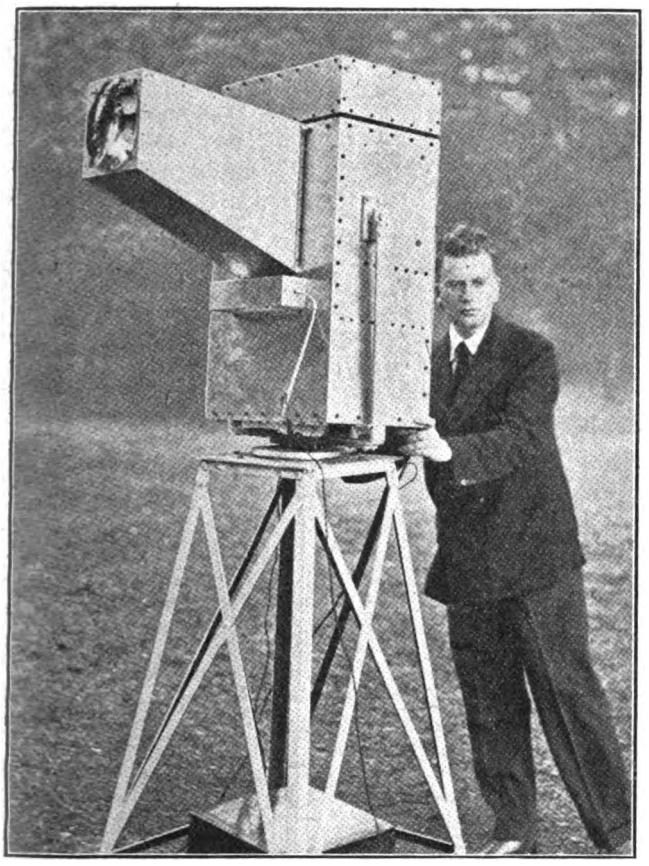


THE NOCTOVISOR—1929.

Mr. J. L. Baird photographed whilst operating his new noctovisor which, slung on gimbals and rotatable about a circular compass scale, can pick up a ship's lights through fog and indicate their compass bearing.

AN "EYE" FOR SHIPS

Remarkable New Invention Renders Fog Transparent

New Triumph for Mr. J. L. Baird

By Our Special Correspondent

IT is exactly two years ago since Mr. Baird demonstrated one of his latest achievements, which he called "Noctovision" before members of the British Association at Leeds. By means of this invention he was able to demonstrate to the assembled members the phenomenon of seeing in total darkness.

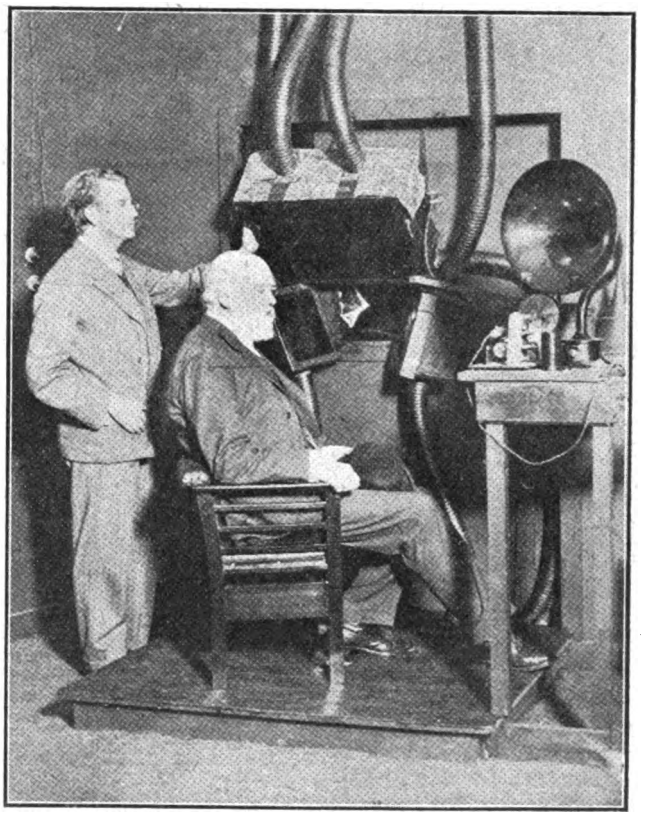
The "Noctovisor," as Mr. Baird christened his apparatus, was the result of a series of experiments upon which he had been engaged, the object of which was to reduce the intensity of the illumination with which it was necessary to flood persons being televised. Mr. Baird found that by using invisible infra-red rays he was able to obtain almost equally good results. To obtain these rays he simply covered the front of the boxes containing his flood-lights with thin sheets of ebonite. These sheets of ebonite cut off entirely all visible light rays, and allowed to pass only the infra-red component.

By switching off the ordinary light in the transmitting room, the person being televised then found himself apparently in complete darkness, and yet at the receiving end the image of his face appeared quite clearly on the receiving screen, and all his movements could be followed by the observers.

On the night of August 9th, last, Mr. Baird demonstrated to a party of journalists his latest noctovision development. In a preliminary speech of explanation to those present Mr. Baird alluded to his earlier experiments, and stated that at the time of his original discovery, Noctovision was simply a scientific curiosity. For some months past, however, he had been devoting nearly all his time to Noctovision, with the object of transforming his scientific curiosity into something of commercial value.

The apparatus he was about to show was, he stated, of definite practical value to ships in fog at sea, because it would enable them to see through even the thickest fog, and pick up the navigation lights of other ships or the light of a Lightship or Lighthouse. Not only could the lights be picked up, but their bearings relative to the ship could be accurately determined.

The experiments which led up to the demonstration have been taking place during recent months, at Mr. Baird's home, situated at the top of



THE NOCTOVISOR—1927.

Sir Oliver Lodge seated before the noctovision transmitter which Mr. J. L. Baird demonstrated to members of the British Association at Leeds, in September, 1927. The boxes contain banks of lamps, but all visible light is filtered out by the sheets of ebonite which cover the fronts of the boxes; only infra-red rays pass through.

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Boxhill, overlooking Dorking, Surrey, and it was there that the public demonstration was given. Incidentally, the release of information concerning Mr. Baird's experiments explains to the people of this part of Surrey the mysterious lights which have been seen during the dead of night.

Mr. Baird had set up the Noctovisor in his grounds on the top of the hill, from whence, in daylight, is obtained a most marvellous view of the neighbouring valley.

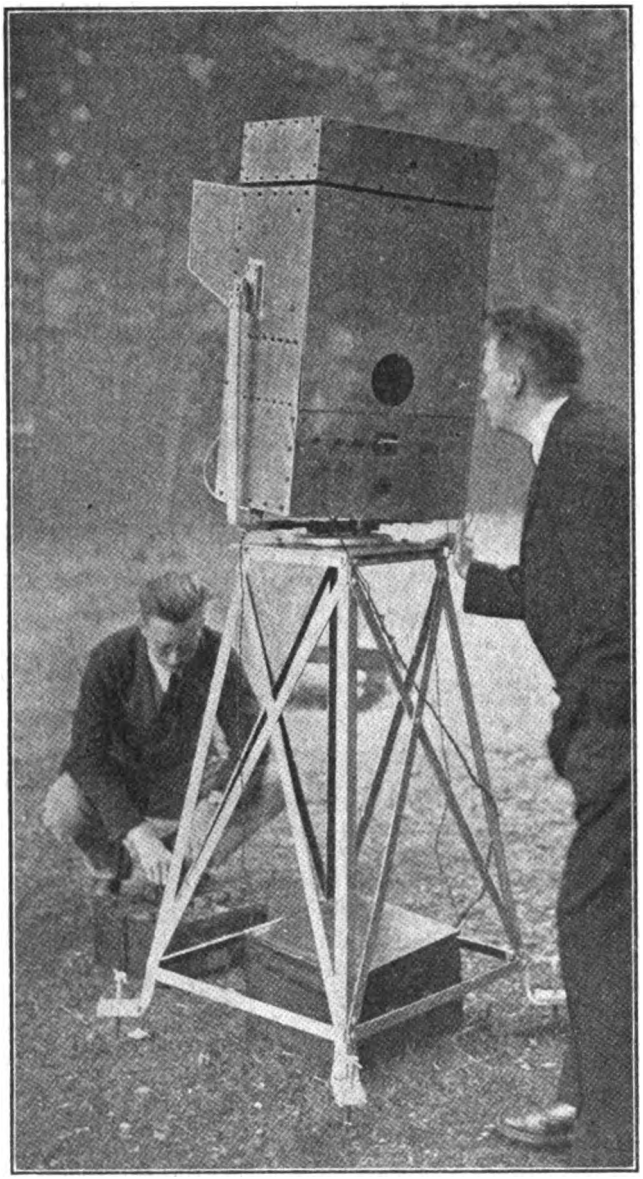
At nightfall a motor car left the house for the valley below. Observers at the house could see the lights of the car as it moved along the main road in the valley, where it came to a stop about three miles away. The car was turned round and one of the headlights directed towards the house on the hilltop.

At a signal from the operator on the hill the headlight suddenly vanished, and all was pitch darkness. The light on the car had been obliterated by placing a sheet of ebonite in front of it, the ebonite being an artificial substitute for fog.

On the hill the operator, acting as the navigator of a supposed ship, was endeavouring by means of the Noctovisor to pick up this hidden light, which for the purposes of the demonstration, was considered to be a light-ship or a lighthouse obscured by fog. The lens of the noctovisor was pointed towards the valley, and the operator permitted those present to look in at a little screen on the back of the instrument as he swept the valley in search of the hidden light. Then suddenly, to the amazement of the audience, on the border of the screen, there appeared the first signs of the missing light which, as the apparatus came into focus, turned into a spot of brilliant orange light. The operator adjusted his apparatus, until the spot of light reached the centre of the screen and then, from a graduated circular scale round which the apparatus revolved, he was able to read off the exact compass bearing of the invisible ray.

As will be seen from the illustrations in these pages, the apparatus is very compact and easily manageable. In essence it consists of a special lens which picks up an invisible ray and projects it on to a specially sensitised cell, the output of which is amplified and conveyed to a neon tube. In front of the neon tube there revolves a scanning disc similar to that used in ordinary television, except that the holes are much larger.

While one edge of this disc is passing in front of the neon tube, the edge diametrically opposite passes between the pick-up lens and the photo-electric cell, in which position the disc functions as an interrupter or chopper, which chops up the infra-red ray beam into impulses. This is necessary so that the output of the specially sensitised cell shall be discontinuous and capable of amplification.



Back view of the noctovisor, showing opening in case through which the viewing screen is watched.

Several Naval and Mercantile Marine officers, who have witnessed demonstrations of the apparatus, unanimously declared that it is one of the most epoch-making inventions of the age. The Chief Officer of one of our largest liners declared that in his opinion, before very long, no ship would proceed to sea without a Noctovisor.

By means of the wireless direction finder, with which all our liners are now equiped it is possible under any conditions, to determine the position of a ship in relation to fixed wireless stations on land or in relation to other ships which may be anything up to a hundred or more miles away.

When ships are within a very few miles of one another, however, it is difficult to determine their exact position by means of the direction finder, owing to the rapidity of movement of the ships concerned. In clear weather, an approaching ship can be seen, and steps taken to avoid a collision, but in foggy weather the direction finder cannot with certainty be relied upon to avoid collision risk, because the closer the ships are together the more difficult it is to determine accurately the position of the approaching vessel. It is in such circumstances that the Noctovisor will prove invaluable to navigators, by rendering fog transparent, and enable them to follow with their own eyes the movements of all ships in close proximity.

In cases also where it is necessary to sail close to a lighthouse or light-ship in foggy weather, the Noctovisor ill prove invaluable.

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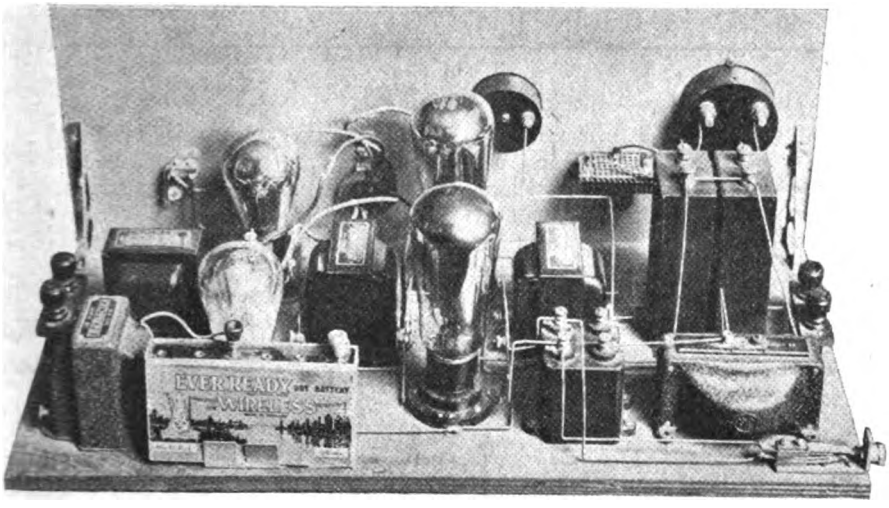
THE CONSTRUCTION OF EXPERIMENTAL TELEVISION APPARATUS

Part IV

By A. A. WATERS

Working in collaboration with Capt. R. Wilson, a member of the Council of the Television Society, Mr. Waters has been engaged on television experiments for some time. Photographs of Capt. Wilson's apparatus, as it is to-day, appear elsewhere in these pages.



This photograph shows clearly the layout of the amplifier. The panel is of sheet aluminium.

IN the preceding articles of this series we have dealt with tools and equipment for the construction of experimental apparatus, such as scanning discs and light sources. We now come to the consideration of an amplifier suitable for use in television experiments.

It must be realised in the first place that a resistance-capacity coupled amplifier is undoubtedly the most suitable for general television work, and may perhaps be considered essential for the advanced worker; but there are several good reasons against its adoption by the home constructor.

Foremost amongst these is the need for a high voltage H.T. supply of from 300 to 400 volts, and the necessity of employing four or five stages of amplification as the minimum for successful shadowgraph or television reception. This is rendered necessary by the low amplification per stage normally associated with R.C. coupling; and is further complicated by the need for careful screening of each stage. However, a similar degree of amplification sufficient for shadowgraph or simple television reception can readily be obtained from a three-stage transformer coupled amplifier, which will function satisfactorily on limited H.T. voltages, and without screening. In our experiments a straightforward transformer coupled amplifier could not be made to give the results that we required, due primarily to the inherent instability of such circuits. Hence it was found necessary to resort to the push-pull system of connection.

By this means a completely stable amplifier has been evolved, which will handle sufficient power in the output stage to operate the usual types of neon tube and derives its H.T. supply entirely from 220 volt D.C. supply mains. No elaborate smoothing circuits are necessary. From this same supply the striking current is obtained for the neon tube, this circuit comprising a choke, *L* (see Fig. 1), variable high resistance *R*, and milliameter, *M*.

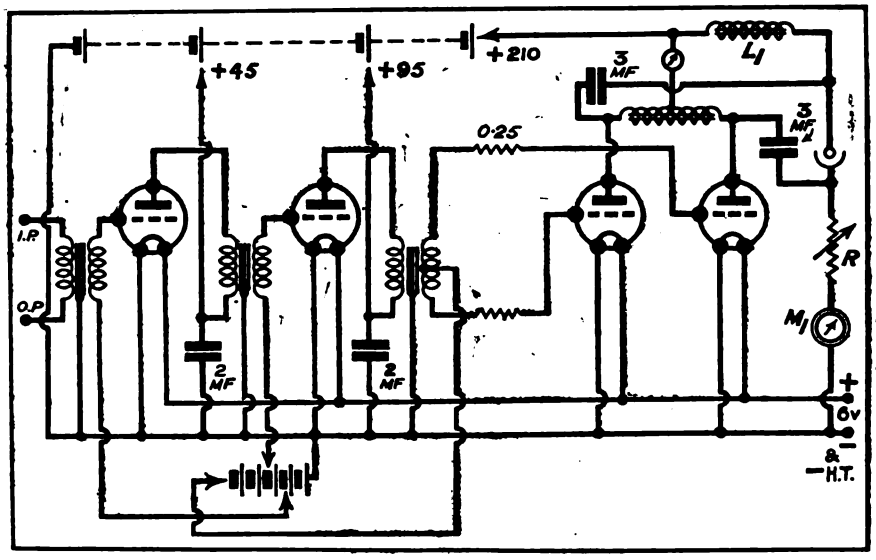


Fig. 1.
The theoretical wiring diagram showing the push-pull arrangement of the last two valves, and the neon tube striking current circuit.

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The H.T. supply for the two preceding stages is best obtained from dry batteries, since very little current is required, and complete freedom from mains noises and interaction between the stages is thus ensured.

From the accompanying photograph readers will readily see that the amplifier is not a very difficult constructional problem. A list of the components used will be found at the end of this article. Some of these components are of American origin, the reason for this being that they had been adapted from other experimental apparatus. I would advise intending constructors to use only transformers and condensers of a reputable make.

The panel is made from 1-16th-inch sheet aluminium, and can be obtained cut to size from any metal stockist.

The first operation is to mark off and cut the large holes for the milliameters. These holes can be cut by drilling a series of small holes that break into each other, and finishing off with a half-round file.

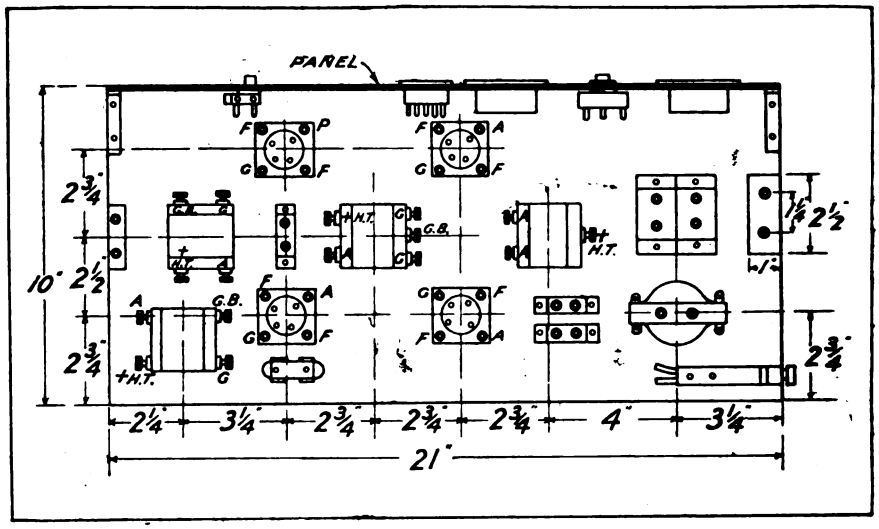

Fig. 2.
The baseboard layout.

When the panel is screwed into place the other components can next be fixed in their allotted positions. A diagram of the lay-out will be found in Fig. 2.

It will be noticed that a seven-way cable connector is used for battery connections, and is fixed to the front panel. The reason for this is to keep all battery connections screened from the set, the panel acting as the screen. This particular connector is of American origin, but there are other makes obtainable in this country.

For the input and output terminals are used and mounted at each end of the set in their respective positions.

The variable resistance should be the heavy-duty type, as it carries the current passed through the neon tube circuit. After trying several types, we found that the true volt wire wound was the only one that would stand up to twenty milliamps. This resistance must be insulated from the panel by means of an ebonite bush and washer, as indicated in the panel diagram, Fig. 3.

(*Continued on page* 344.)

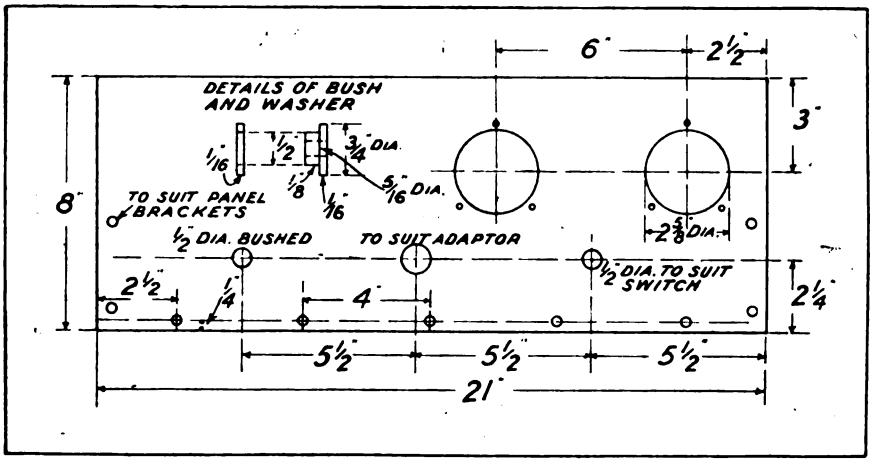

Fig. 3. The panel layout.

When all the holes have been cut, the question of obtaining a finish to the front of the panel had to be settled. This was accomplished by the use of black crystalline paint, which gives a very nice appearance if the maker's instructions are carefully carried out. In our case the paint was applied with a brush, and the baking was done in a gas oven, and it came out surprisingly well.

The baseboard is made from five-ply wood. I recommend this wood so that warping troubles do not creep in when the amplifier is completed. In a great many home-constructed wireless sets I have seen a bad baseboard, which has spoilt the results from the beginning,

List of Components.

- 1 panel 21 inches × 8 inches × $\frac{1}{16}$ inch sheet aluminium.
- 1 Baseboard, 21 inches × 10 inches × ½ inch, 5-ply.
- 1 pair 6-inch panel brackets.
- 4 valve holders (Benjamin).
- 1 L.T. switch (Yaxley).
- 1 push-pull transformer.
- 1 push-pull choke centre tap.
- 2 transformers, 3 to 1 ratio.
- 1 32-Henry choke (Pye).
- 3 2-μF condensers, type BB Dubilier.
- 2 2-μF condensers, type LAC, Dubilier.
- 2 0–50 range milliameters.
- 1 seven-way battery connector and socket.
- 1 50,000-ohm variable resistance (True Volt).
- 1 G.B. clip.
- 1 G.B. 9-volt battery.
- 4 ebonite terminals.
- 1 2-point jack.
- 3 coils Glazite.
- 2 2½ inches × ¼-inch pieces of ebonite.
- Wood screws.

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How Television will Kill "Time"

New Worlds for Old

A Special Article written exclusively for "Television"

By SHAW DESMOND

Author of "Echo," "The Isle of Ghosts," "Ragnarok" (a story of the coming Armageddon), etc.

THREE of us sat in an upper chamber, remote from the fret and suck of the city's tides beneath. It was a queer room, full of curious drawings, of strange, almost chimerical, instruments, of screens—now milk white, now shining like mirrors under the summer sun.

From far below came the roar of the motor-buses; the cries of the newsboys; and the hoot of the taxis. All the *earth-bound* movement of our day.

And then, as we looked down, there came the ominous thrud-thrud of something above us, and a shadow as of a great black bird was flung upon our screen.

As the giant Handley-Page bomber roared overhead, with its attendant sprites, Fox scout-planes, turning and twisting in the central blue, one of the three, an engineer known in four continents, said quietly:

"All that below is passing. All that above is coming." And then, after a moment, the words, penetrating, low:

"Look up! Not down!"

What the motor car was to the horse, and the aeroplane to the motor-car, the "televisor" will be to the aeroplane . . . and to the world. It is only because our imaginations are *earth-bound* that we have not seen it.

For it is television that is going to wipe out space and, above all, wipe out *time*.

In the world of the future, time, as such, will have no existence. It will be as dead as Adelphi melodrama or crinolines. We, human beings, will no longer reckon our little lives by watches and clocks, but by *events*.

Before twice a dozen of years have petered out into eternity we may have neither motor-bus nor taxi in our streets. As for the newsboy—his yell will by then be extinct as the yell of his forbear, the Red Indian.

For, as will be seen, the newspaper will be literally televised into the home. Simultaneous publication of the world's great newssheets will be such a common-place, through the medium of the "televisor," that the tutored African savage, an he will, will be able to read the London *Times* in the streets of Johannesburg or Durban *at the moment of its printing* in the present capital of the British Empire and of the world. "Present" I say—for the world's capital by that time may be New York or Toronto or Timbuctoo! Things change so quickly to-day.

For the world is moving. As old Galileo said: "It moves."

Nay, more, the world as we knew it, and know it, is passing never to return. The "televisor" is going so to obliterate the old landmarks that were we to come back within, say, fifty years we should not know the world we had left, save by its buildings—and not by many of those, for the skyscraper is coming.

* * *

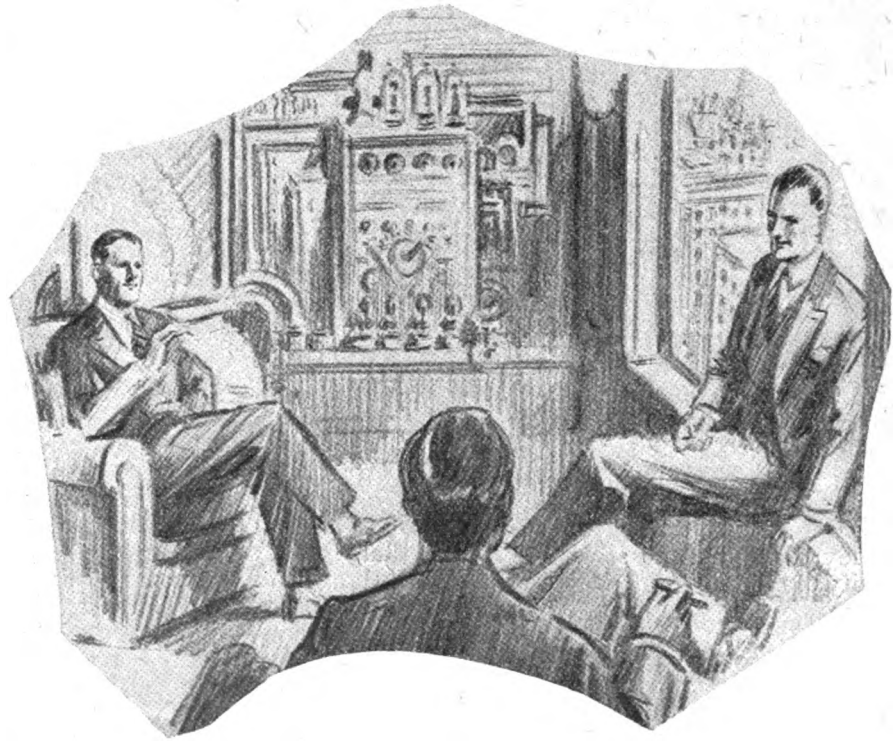
I walked out from that meeting in that room, where the history of our day is being made, to London's new circular underground station at Piccadilly.

In front of me was a big lighted screen. Over the top:

WHAT'S THE TIME ?

It was prophetic.

There, within ten minutes of my friend saying "Look up!" and my own prophecy of the abolition of time by seeing at a distance, I found myself looking at a screen before



"Three of us sat in an upper chamber . . . full of curious instruments, of screens—now milk white, now shining like mirrors under the summer sun."

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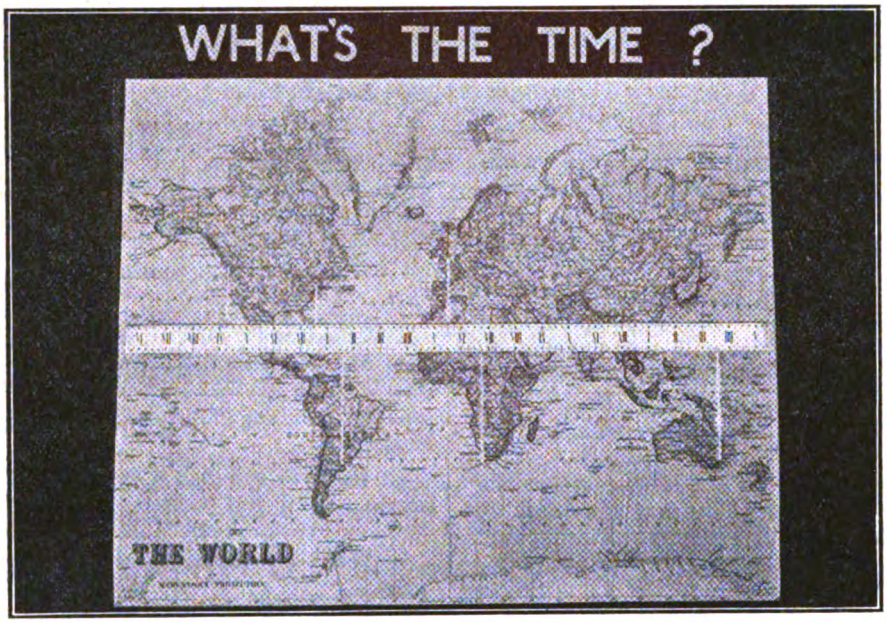
which crowded the underground passengers, waiting to be diabolically transferred underground by the purring escalators—there I saw a picture of the world that is coming.

There was India and Australia, Africa and Russia, the South Sea Islands and the Arctic Circle. And across that tiny little world, once so vast, there moved a band of light, shading from the white glare of noon to blackest midnight. Along that band stood the now obsolescent hours of time — twenty-four of them, showing the time in Bagdad and London, in Morocco and Bombay, in Tanganyika and Peru. All twenty-four of them melting into one another, as above them there flew the passenger planes of to-day, and above them the ether tingled with wireless. And now, soon . . . the passage, swift, immediate, of tens of millions of eyes, all **seeing at a distance** still further to obliterate time.



[*Photo. courtesy London Underground Railways.*
The World Clock, Piccadilly Circus Underground Station, London.
"In front of me was a big lighted screen."

The rapid development of international telephony over thousands of miles of sea and continent has already done much to show us the futility of time as we know it.

* * *

We are now, to render time still more meaningless, within easy distance of the 500-mile an hour passenger plane. Louis Blériot, modest great one, is now ready with his plans for the new ocean aerodromes, floating harbours to withstand any sea and any tempest. Within a few years the great passenger airliners, not gas-balloons, but helio-coptered cigar-shaped metal ships of the air, will be carrying their two - thousand - passenger cargoes across the Atlantic between sunrise and sunset—perhaps within the periphery of a summer morning. And, even to-day, the "Moth" plane lies waiting to "taxi" the solitary passenger from his private door to his business or his pleasure, as I have seen them before the doors of private houses in Florida.

Yet all this is but the play of children, when compared with the Baird "televisor" as time abolitionist!

Whether Baird, most modest of great scientists (and often most neglected!), knows it or not, he has loosed upon this earth of ours legions of genii, omniscient and omnipresent. He has made men as gods.

For the quality of all gods is just that capacity of being present everywhere, and especially of *seeing* everywhere at the same time. And I, poor mortal, am wondering how we humans, who so shamefully misuse both our great inventors and their inventions, are going to use this invention.

We will still go on babbling about "the time of day." We will still carry on our footling wrists our footling little wrist watches, lift our footling sleeves, and look footlingly at a dial that will have ceased to mean anything.

We shall still "make appointments," and grumble because the other fellow doesn't keep 'em. We shall still think in terms of day and night—when, as a matter of fact, day and night as such will have ceased to exist.

* * *

What meaning will the old terms "day" and "night" have when the Baird "televisor" (and there really is no other televisor worthy to-day of serious consideration) will "televise" the editorial page of the *Times* to Sydney or Melbourne or Calcutta or Hong-Kong? And not only the editorial page but those other pages, advertisements and all!

No more playing about with the little crankly cumbersome telegraph. No more "long distance telephoning," with its innumerable stops and "faintings."

There in the newspaper offices of Hong-Kong or Calcutta will be the "televisor" screen. There on that screen, fast as the pages are printed in London, will they appear, page by page, complete and *instantaneously*. And there, still in Hong-Kong or Calcutta, fast as they appear, they will be "processed" and made ready for the giant machines waiting to vomit them out to the waiting thousands.

* * *

Here is the virtual League of Nations and Parliament of Man of which the poets, but never the politicians, dreamed. For nothing kills prejudice like knowledge. And nothing makes war like prejudice.

In the day when the "televisor" shows the peoples of the world to one another as they are *at the moment of happening*—not weeks after when the effect has passed—in that day war will have become more remote than ever before.

In the day when China's four hundred millions can see Europe's three hundred millions at work and play, and read about them in those "pictures" which are to-day the universal language, then the "unchanging East" will have gone farther towards the changing West than a thousand years of ordinary propaganda could accomplish.

The "televisor" is the missionary of civilization.

* * *

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People to-day think in pictures. The war, plus the cinema, has accomplished this—the war by breaking up men's minds and forcing them away from steady novel-reading and book-reading generally; the cinema by offering to the already broken mentality the easiest of all assimilations.

I believe that some of this is bad, and that some of it is good. But, good or bad, there it is.

The ostrich-like policy of sticking our heads in the sand, as some great wireless institutions have done, and refusing to recognise it, is just "ostrich." Britain often "goes ostrich."

Within a breath, every home in Great Britain will have its own "televisor" screen. Within a couple of breaths, even the remotest hamlet in the Balkan volcano, and the remotest Russian *mir*, will have its television screens.

The Omsk peasant will be able to see the planes of that day flying over St. Paul's, see the members of the Stock Exchange doing business upon the Throgmorton Street curb, or, by a turn of the switch, watch the American brother doing his business upon the Wall Street curb, which by that time may have swallowed the world!

When the peoples of the world find out how much alike human beings are—and how different!—it is likely to make them regard war as stupid where it is not mad, and foolish where it is not criminal.

The peace monuments of the future will be erected to men like Mr. Baird, rather than to the founders of Leagues of Nations.

* * *

Now out of this call to the wide, wild world of the "televisor" will come many things, inevitable it seems to me as that day should follow night . . . for the present. For soon *there is going to be no day and no night.*

With simultaneous communication by air and wireless, physical and mental, people will begin to chafe, as, indeed, they have already begun to chafe in America, at the arbitrary division of light and darkness. We cannot, at least not as yet, though I do not say that *anything* is impossible, prevent the earth from turning round on its crazy old axis every twenty-four hours, even though Edison once showed me in his West Orange laboratory a possible way of "harnessing" that turning. But we can neutralize both light and darkness.

We already do the former every day of our lives when we curtain our rooms when we want to sleep in the daytime, and enormously increasing numbers of people, who are night-workers, do sleep in the day. As for the latter, we shall, I have no doubt, cover in our cities by some of the new flexible glass, using some of that new artificial "daylight" generated by the electric suns, which I have seen in Chicago, and keeping the suns going when the sun is down.

A terrible prospect, you say? Unnatural!

Why, my dear sir and madam, everything in our day is unnatural! You are unnatural. I am unnatural, And, if I may ask it, what, really is "nature"?

When that glass-roofing and artificial daylight come we shall find the working day divided into three sections, irrespective of light or darkness, each section working, say, eight hours. We shall find the community also divided into three sections, more or less, and boating and swimming and theatre-going in full swing, *not* any hour of the day or of the night—but of the twenty-four, for the terms "day" and "night" will then be meaningless. For I suppose we shall, for the time at least, use the twenty-four unit until it becomes archaic.

* * *

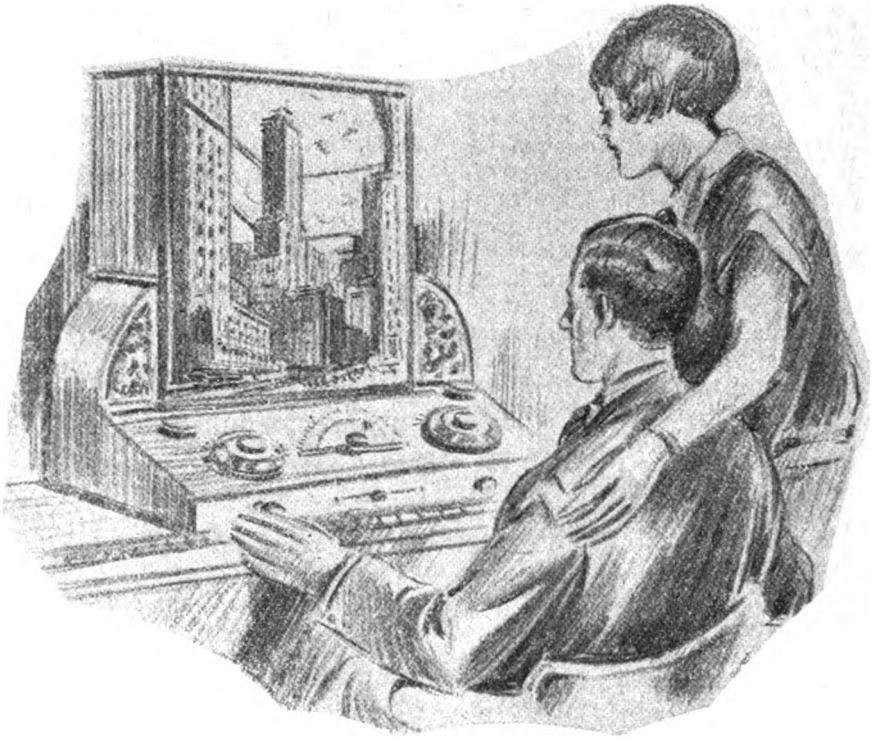
With all this will go regulation of climate.

In the time that is approaching man, who now has inexorably harnessed the tides of the world and the earth-currents, will also harness climate.

No longer will *homo sapiens*, that queer, restless, searching animal, tolerate cold or heat where he does not want cold or heat. Why, if he will, he will melt the ice-caps on the Poles, where one day he may grow oranges.

From a long conversation which I had some time ago with Edison, followed by others with the foremost continental and British minds in the world of electricity and physics, I have no more doubt than that I am alive that we are on the edge of the harnessing of atomic energy. As Edison said, quietly: "It is coming."

There is contained in half a glass of water enough atomic power to lift



"... by a turn of the switch, watch the American brother doing his business upon the Wall Street curb."

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the British fleets to the top of Mount Everest. **There is, in the idea of the Baird "televisor," such power of potential projection that I am convinced that "seeing at a distance" is but one of a hundred other applications of his great discovery.**

It is by atomic energy that one day we shall be able to "pump," or project in one way or the other, the cool polar currents to the tropics, and *vice versa*. We shall make climate at will. We are going to show this little old earth, as our New York neighbours call it, "where he gets off."

A wireless from torrid Suez or roasting Bombay, when that day comes, will bring by return such a flood of cool air as will make those portions of Egypt and India as refreshing and equable as a London May. The Polar Observatories, north and south, will ask for a little more heat, and will get it.

And so with the change of climate will come the change of the flora and even the fauna of the countries of the earth.

We shall be able to solve the "short period" Canadian wheat crop, about which I spoke some time ago with another most neglected scientist—at least by his own countrymen—Professor Biffen, of Cambridge, a man to whom the British Empire owes nearly as much as to Sir Ronald Ross, of tropical medicine fame, whom an ungrateful British world has left to sell his valuable manuscripts in order to keep his research going. We shall make our crops anything from twelve weeks to twelve months, as we will.

* * *

But none of this would have meaning in the deeper, human sense if human beings could not *see* one another all over the world at the same time.

We are going to have simultaneous communication by eye and by voice. **A voice without an eye is a dead thing. A voice *with* an eye is vibrant, living.**

And there is no human being of us all who one day will not be able to see any other human being by his pocket-televisor and hear him with the tiny telephone attachment which in that day will be worn like the watch to-day, in the waistcoat pocket or on the wrist.

* * *

The fact is, that we are on the eve of reducing the world to the size of a house, and making the whole world a place of instant inter-communication by sound and sight—perhaps some day by taste and smell!

And if there be doubting Thomases, who, reading these lines, may consider that the imaginative powers of the writer have outrun his discretion, I would only say to them: Oh ye of little faith! If anybody had told your great-grandmothers that their stage coaches doing a giddy fourteen miles an hour would be replaced by steam trains doing sixty, what would they have said? Nay, what *did* they say?

And if anybody had told your fathers that on the common roads we should one day have road-hogs doing their cool seventy to the danger of themselves and the public—what would they have said? Nay, again, what *did* they say when they put a man with a red flag to walk before the prehistoric motor-car?

And now that someone is telling you and showing you that man has gone up into the air to defy the force of gravity, and to do his cool 300 an hour—do you not all take it as natural, scarcely, indeed lifting your sapient heads to "rubber" the upper regions?

But when a prophet comes along to tell you that the day is coming when the whole world will be hung on wireless—when seeing and hearing at a distance will be the commonplace of every day, when climate will be controlled, and when there shall be neither day nor night . . . you look down your noses.

"Oh, ye of little faith!"

(*Copyright in all countries.*)

Experimental Television Apparatus

(*Concluded from page* 340.)

There are two milliameters incorporated in the circuit. One is used for reading the current supply on the anodes of the last two valves, the other is inserted in the D.C. feed to the neon tube.

It will also be noticed that there is a jack incorporated, which will enable a loud speaker or phones to be connected to the output. The wiring is a fairly straightforward operation, and Glazite is used, except for the connections to the multi-connectors, which are rubber covered and supplied with the adapter.

The selection of suitable valves depends upon the stock of the experimenter, but the first two valves can be of the D.E.L. type, the last two should be of as low A.C. resistance as possible, and to obtain the best results they should be matched. In the amplifier which I have described two D.E.L. 610 and two matched P.X. 650 were used. When the amplifier is ready for use it will be found advisable to keep the input leads from the light sensitive cell as short as possible, also to shield them with flexible metal tubing, which should be earthed together with the negatives of the batteries.

A negative bias of about 3 volts is desirable for the correct working of the first valve, and this is obtained from the 9-volt grid battery seen in the photograph. All the other voltages are supplied through the connector, the first valve having 45 volts on its anode, the second 90 volts with about 4 volts negative bias, and the two P.X. 650 have 200 volts with a negative bias of about 40 volts. These voltages are given as approximate, as it was found that by slight adjustment of grid bias voltages the best results are obtained.

The actual connections which feed the neon tube circuit are not shown in the photograph, but will be seen in the circuit diagram, the positive of the D.C. mains going to choke, and the negative to resistance. Terminals can be adapted if the experimenter wishes, but this was not done, owing to the experimental nature of the amplifier. In closing, I would like to mention that this piece of apparatus has given very useful service in a great many of our experiments, and is regarded as a standby for future work. If the intending constructor meets with the same success as Captain Wilson and myself, I do not think he will be disappointed.

In the next article I will describe some of our later experimental apparatus.

EXPERIMENTAL work. Inventors' models. Scanning discs any size to drawings.—JOHN SALTER, Scientific Instrument Maker (Established 1896), Featherstone Buildings, High Holborn, W.C. 1.

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The Literature of Television

By J. H. OWEN HARRIES, A.M.I.R.E.

When the student commences the study of a subject which is new to him, he invariably experiences great difficulty in ascertaining just what literature there is available on the subject, and just which of the many books and articles will be of value to him. If the subject in question is a new one entirely, then the difficulties are still further increased, for there is in that case scarcely any literature of value. The science of television, although still very new, has already an extensive bibliography, and Mr. Harries gives below a list of some of the works of reference, and where they may be found. He also gives brief summaries, and details of a useful reference system which he practises.

THIS article is an effort not so much to give a complete bibliography of television—such an aim would be an impossible one in the space available in a periodical—but to point out sufficient sources of information to enable a student of the science to gain a clear and first-hand knowledge of the present state of progress.

In the main this summary is limited to the older classical papers on the subject, and the reader is assumed to be able to keep himself abreast of current development over the period covered by recent issues of TELEVISION but, as a guide to the beginner, some later articles are included also.

It will be found that if the references in the various papers are followed up a very complete treatise on television will have been read.

Of course, the correct and scientific way of presenting this article would be to classify all the references under the excellent Dewey reference system; and for those with the time available the formation of a library indexed on this principle can be heartily recommended, but for most of us with less leisure the system of heavy type headings actually adopted was considered the best compromise.

With the aid of this, and the classification into sections according to the nature of the information given in each thesis mentioned, it is hoped that reference to any desired authority will be found easy.

1. THEORETICAL.

Dr. H. E. Ives on Television. "Bell System Technical Journal," October, 1927, pp. 551–559.

An introduction to the well-known series of papers by the American Telephone and Telegraph Company in this issue of their journal; and a review of the chief problems to be overcome.

Correspondence in the "Times" between Messrs. A. A. Campbell-Swinton, F.R.S., C. R. Cosens, N. Edwards and Dr. W. J. Robinson, and an article by the "Times" wireless correspondent in the issue for August 8th, 1928. The letters appeared in the following issues: July 20th, 24th; August 4th, 15th, 21st, 27th; and September 10th, 20th, and 28th.

Whichever side one takes in this controversy—and it is far easier to choose now than when it occurred—the points raised by the contestants are of great interest.

Problems of Television. By Prof. Fournier d'Albe. A report of a lecture at Oxford by the Professor. "Wireless World," March 24th, 1926, Vol. XVIII., p. 461.

This and the next item are of importance as being one of the first, if not the very first, efforts to prove the impossibility of successful television by means of the now well-known "dot" theory. These and the preceding correspondence should be read in conjunction with the other later papers given below, and the reports of modern television results given elsewhere.

Television: A Criticism. Denes v. Mihaly. "Experimental Wireless," April, 1927, Vol. IV., p. 239.

One of the first attacks on Mr. Baird.

Television: Past and Future. By A. A. Campbell-Swinton. "Discovery," November, 1928, Vol. 9, pp. 337–338.

Whether one agrees with Mr. Campbell-Swinton or not in his enthusiastic damning of television as known to-day, the historical data he gives is of great interest. He states that the revolving disc with apertures was patented by Nipkow in 1884; mirrors on rotating wheels were proposed in 1889; and even the scanning by a moving beam was patented by Ekstrom in 1910.

Amount of the Ether Required by Television. By Dr. J. Robinson. "Television," December, 1928, p. 5.

A consideration of modulation of the waves sent out by a broadcasting station, and the author's reasons for considering that the band widths needed by commercial television in the future will not be impracticably wide. (See also Dr. Robinson's previous article, "TELEVISION," November, 1928, pp. 9–11.)

Some Figures on Modulation in Television. By J. C. Rennie. "Television," Vol. I., No. 9, p. 8.

He refutes the "dot" criticism of television.

A Quantitative Analysis of Television. By J. H. Owen Harries. "Television," May, 1928, pp. 105–112.

A thesis suggesting a system of measurement of the quantities of television, with the object of interpreting and extending the data found by research.

Criticised by Sir Ambrose Fleming ("Television," June, 1928, p. 161), who suggests other empirical factors.

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An extension of the theory and a reply to Sir Ambrose by the author in "Television," July, 1928, p. 259. The report of an informal discussion before the Television Society will be found in the Proceedings of the Society for June, 1929.

Can Frequency and Phase-Change Modulation Reduce Interference? By J. H. Owen Harries. "Television," August, 1928, p. 310.

A semi-mathematical article in which the author gives his reasons for answering the question in the negative as far as published suggestions are concerned.

2. SYSTEMS OF WORKING AND DESIGN.

An Account of Some Experiments in Television. By J. L. Baird. "Wireless World," Vol. XIV., May 7th, 1924, p. 158.

Probably the first article published by Mr. Baird on this subject. It describes his earliest shadowgraph results.

Television: A Description of the Baird System by the Inventor, J. L. Baird. "Wireless World," January 21st, 1925, Vol. XV., p. 533.

A continuation of the above article. This one described his first success with a crude image of the head.

Television: A Paper by Mr. J. L. Baird, read by Lieut.-Col. J. R. Yelf before the R.S.G.B. on October 26th, 1926. Reported in "Experimental Wireless," Vol. IV., p. 730, December, 1926.

This gives a brief historical survey of the work of various investigators. The principle of an early Baird televisor carefully explained with diagrams, and a photograph of an image on a television screen. The discussion concludes the report.

Mr. J. L. Baird's Lecture before the Television Society. "Television," No. 4, Vol. I., pp. 9–15.

A fairly comprehensive qualitative account of his systems of television, noctovision, phonovision, etc.

Baird's Stereoscopic Televisor: Verne. "Television," Vol. I., p. 20, Part 7.

An account of this apparatus and a photograph.

Baird's Patents. By a Patent Agent. "The Wireless Constructor," October, 1928, p. 497.

A summary of his first patents for disc and scanners, double light source, optical lever, stereoscopic television, etc.

Baird Noctovision Patent. Pat. No. 288882. App. date October 15th, 1926.

Noctovision. By R. F. Tiltman. "Television," p. 42, No. 1, Vol. I.

A qualitative article on this invention, illustrating the ether-wave frequency spectrum.

Synchronisation in Television. By A. Dinsdale. "Television," Vol. I., pp. 26–29, No. 3.

An account of the various systems in use. Ranger's and the synchronous motor system. An explanation of synchronism, isochronism, and phasing. Baird's patent for phasing No. 236978, March 17th, 1924.

Television System of the A.T.T. Company, New York. "Bell System Technical Journal," October, 1927, pp. 551–652.

A series of five papers which are considered to form probably the best single thesis on television yet published. A full and detailed exposition of all parts of the successful "head and shoulders" system worked by this company. The quantitative consideration of aperture distortion is especially valuable.

Photo-telegraphic System of the A.T.T. Company, New York. "Bell System Technical Journal," April, 1925, Vol. IV., No. 2.

A very well-illustrated and informative thesis.

Scanning Aperture Patent. Brit. Pat. 288237. Elec. Research Prod. Inc.

Contains another mathematical consideration of aperture design.

The Principles of Image Scanning. By Dr. J. Robinson. "Television," No. 9, Vol. I., November, pp. 9–11 and 26.

A non-mathematical consideration of the distortion caused by scanning holes, and a reply to the "dot" criticism of existing television systems.

Optical Conditions for Direct Scanning. By Ives and Gray. "Journal Op. Soc. Am.," December, 1928, Vol. 17, pp. 428–434.

Direct scanning is now used again, i.e., not the light-pencil system. Lens systems discussed. Apparent physiological effect of 50-line images in showing full-length scenes far better than one would expect by analogy with that found in the case of faces.

Radio-vision "Science." "Science," November 16th, 1928, Vol. 68, Supplement, p. xii.

"50-line images will give much better results with full-length pictures than was anticipated from those obtained with faces."

Some Notes on Scanning. By R. R. Poole. "Television," July, 1929, pp. 221–224.

A description of a machine exhibited before the Television Society for demonstrating scanning, and an analysis having particular reference to the not very well known distortion produced by the time taken to completely scan a moving object by the moving apertures.

Alexanderson's Systems of Photo-telegraphy and Television. By A. Dinsdale. "Wireless World," Vol. XV., p. 476.

The systems described, multiple light spot method, pictures sent, experimental drum televisor, "sluggishness" of transmission aerial.

Television Demonstration in U.S.A. By A. Dinsdale. "Wireless World," Vol. XX., p. 510.

A full account of the "1000 men" demonstration of the Bell Telephone Laboratories.

Jenkins' Shadowgraph Experiments. "Television," pp. 26–28, Vol. I., Part 7.

An account of this non-synchronised cinema film transmitter. Multiple electrode tube at receiver.

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Radio-vision. By C. F. Jenkins. Proc. Inst. of Radio Engineers. Vol. 15, 11, pp. 958–968.

His methods in outline.

Karolus System of Television. By Dr. Neuburger. "Television," Vol. I., Part 8, pp. 35–37.

A number of photographs and an account of his cinema film and solid object transmissions. Lenses and Kerr cell used.

Jenkins' Radio-Movie Transmission. "Radio News," November, 1928, p. 420.

A description of system. Motor geared to disc by sliding wheel on periphery of the disc instead of employing automatic synchronising apparatus.

Radio-Drama and Full-length Boxing Match Televised. "Radio News," December, 1928, pp. 524–27 and 587.

A boxing match and play seen clearly. Former by 12 in. by 12 in. screen full-length pictures, and latter by fading in and out between small "head and shoulder" television cameras. Dr. Alexanderson's and G.E.C. of America systems respectively.

Complex Televisors Give Large Images. By Herndon Green. "Radio News," December, 1928, p. 536.

An account of Mr. C. F. Jenkins' system in America, with particular reference to his large receiving frame, studded with small lamps which are energised one by one by a commutator drum. He claims that light limitation is overcome by this method. Illustrated.

The Possibilities of Television. By A. A. Campbell-Swinton, F.R.S. A Paper read before the R.S.G.B. March 26th, 1924. Reported in full in "Wireless World," Vol. XIV., p. 51, April 9th, p. 82, April 16th, and the discussion reported on p. 114, April 23rd, 1924.

This is the original exposition of Mr. Campbell-Swinton's suggested cathode ray system, which has been the subject of so much controversy since. The opinions given by various engineers in the discussion are specially interesting in view of modern development.

Patent on Cathode Ray Television. Westinghouse Electric Company and V. K. Zworkin. Brit. Pat. No. 255,057; July 13th, 1925.

This is the classical cathode ray television patent. The explanation is very full indeed, and should be read by all interested in this avenue of research. By means of coloured mosaic screens coloured television is claimed.

Television by Cathode Rays. By A. A. Campbell-Swinton. "Modern Wireless," June, 1928.

The method is discussed and urged by Mr. Campbell-Swinton as the only possible solution. Previous patents and a bibliography and historical notes.

The Cathode Ray Oscillograph. By Dr. A. B. Wood. "Journal Inst. of Elec. Eng.," November, 1925.

This is a very good technical article with an excellent bibliography. It is one of the best expositions of the technique of this device. Other papers in the same issue of the "Journal" are also of importance.

The Cathode Ray Tube in Practical Television. By W. G. W. Mitchell. "Television," February, 1929, pp. 38–41.

A review of the difficulties of the problem and some historical data.

The Cathode Ray in Practical Television. By W. G. W. Mitchell. "Television," May, 1928, p. 129.

The practical difficulties in the way of the successful use of this device.

Belin's Experiments in Picture Transmission. By Dr. J. H. T. Roberts. "Modern Wireless," p. 562, Vol. I., 1923.

This early work carefully described.

Light-sensitive Cells. By W. G. W. Mitchell. Lecture before Television Society. Reported in "Television," Vol. I., No. 5, July, pp. 16 and 31–37.

A most informative lecture. Selenium. Photo-conductivity and emissivity. Unequal response to different wave-lengths. Baird's first differential method of overcoming lag. Bridge methods. Inertia. Manufacture. Priming illumination. Zworkin tube, etc.

3. HISTORICAL AND GENERAL.

Daylight Television. By Dr. J. A. Fleming, F.R.S. "Television," July, 1928, Vol. I., No. 5, pp. 5–7.

The writer's opinions on Mr. Baird's system, and its various modifications.

Criticisms and Critics of Television. By Dr. J. A. Fleming. "Television," November, 1928, pp. 5–7 and 46.

A defence of Baird's system.

Television Abroad (in England). By A. G. Ingalls, Assistant Editor of "Scientific American." "Scientific American," December, 1928, pp. 550–552.

His conclusions are that Baird's results are not so much better than, as different to, the American methods.

Baird: "Amateur Wireless." October 6th, 1928, p. 502.

A very careful and detailed account of the results shown to their representative by Mr. Baird. One of the best descriptions published.

Standardisation of Television Apparatus. "Nature," December, 1928, Vol. 122, p. 853.

In the U.S.A. 48-line, sixteen-a-second pictures are standard. "Nature" remarks that such results are much inferior to those of Mr. Baird.

The Progress of Television. A Reprint from the "Times," March 7th, 1929. "Television," April, 1929, p. 76.

An encouraging review of the Baird television of "head-and-shoulders" images. "A watch (of the rather large turnip variety) was exposed to the television eye, and the present writer read the time as one minute to three. The actual time was one and a half minutes to three."

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The Early History of Television. By J. Strachan, F.Inst.P. "Wireless World," June 11th, 1924, Vol. XIV., p. 305.

The various workers on the subject up to 1882.

Seeing by Electricity in 1880. "Television." Vol. I., p. 8, No. 2.

An account of Carey's system of shutters.

European Progress in Television. By W. J. Brittain. "Science Progress," January, 1928, Vol. 22, pp. 493–494.

"A short but comprehensive survey of the various television systems."

4. BOOKS.

There is no large complete treatise on the science published as yet, such as would correspond to the standard authorities on the older branches of engineering, but the following will be found of considerable help, to the learner especially.

"Practical Television." By E. T. Larner. Published by Ernest Benn, Ltd.

"Television." By A. Dinsdale. Published by the Television Press, 26, Charing Cross Road, W.C. 2.

5. LIBRARIES.

In general most of the back numbers of the periodicals mentioned can be obtained within a few days from any bookseller. The time is much longer in the case of foreign papers, and one may often save much by looking up the references in a public library first.

For those who have access to it the library of the Institution of Electrical Engineers will be found very complete. There is also the library at the Imperial College, South Kensington, London.

At the library of the Patent Office, 25, Southampton Buildings, Chancery Lane, W.C., it is possible to have photographic copies made of papers in the library at a cost of a few shillings.

Patent specifications are sent out by the Patent Office by post at a cost of a shilling each, or may be purchased in the building, but those whose researches are confined to their spare time should remember that the sales department closes at the somewhat early hour of 4 p.m., although the library is open until much later.

6. CLASSIFICATION OF DATA.

The ideal way of indexing is undoubtedly the numerical Dewey system, but it is a long job to arrange the large mass of data most of us have by us on these lines.

For those who can spare the time or are only beginning their collection, it may be of use to refer to an excellent series of articles on this system in "Experimental Wireless," Vol. II,, 1924–25, pp. 3, 67, 131, 195, 259, 327, 385; in the issues for October, November, December, 1924, and January, February, March, April, 1925, respectively.

To get the best out of the system it is as well to send for the circular of the Bureau of Standards, No. 138 —"A Decimal Classification of Radio Subjects: An Extension of the Dewey System." It can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C., U.S.A., price 10 cents (fivepence), plus postage.

(*Continued on page* 351.)

95 Date	Title	Author	Description	96 Reference
20th June '24	KAROLUS-KERR LIGHT CELL PATENT	A. KAROLUS	The Karolus modification of the Kerr cell and Nickel prisms to modulate light electrically	B. PAT. 235857 Con date 30th June 1924. (Abstract in E.W.&W.E. Vol 3 p. 713.
Ap. 1925	COMMUNICATION BY OTHER THAN IN GENERAL USE (INFRA RED RAYS LIGHT BEAM SIGNALING)	BLAKE	A very fine lecture on all sorts of radiation and its source and history Methods of modulating light. Discussion	Before the Radio Soc. at the IEE. Report in E.W.&W.E. p 561 V. 2
April 1927	ALEXANDERSON'S SYSTEMS OF PHOTO-TELEGRAPHY AND TELEVISION	DINSDALE	System described in brief "Sluggishness" of tuned transmission aerial. Pictures sent. Multiple light spot method. Light drum television. Gain in light.	Wireless World Vol XX. p 476

Fig. 1. A method of classifying references. A reproduction of a typical page from Mr. Harries' notebook.

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CONCERNING NEON TUBES

Some Practical Details

By W. C. FOX

In another part of this issue another contributor describes how the gas neon is obtained. In the following article Mr. Fox gives us some practical details concerning the method of manufacture of neon tubes.

TELEVISION, like most other inventions, owes its existence to a number of discoveries which, although heard of now by many for the first time, have in reality spent many years in Science's lumber cupboard as interesting, but more or less useless, curiosities.

This, among other things, is true of neon and similar gas-discharge tubes. It is true neon tubes have been used of late years as sources of illumination for stunt advertising purposes, and for occasional domestic illumination where a very small amount of light is wanted, but no one would suggest that it was fulfilling a purpose for which it was really suited.

Crookes Tubes.

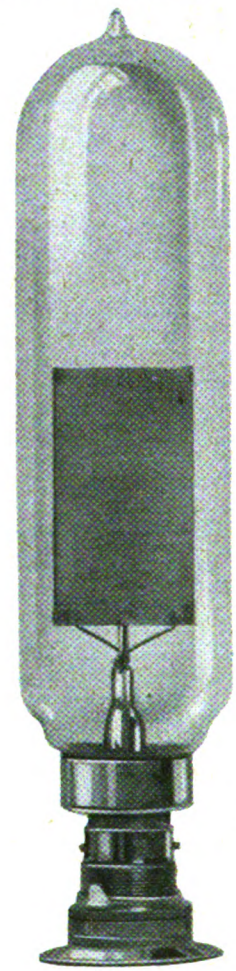
Electric discharges through partially exhausted tubes filled with gas were investigated as long ago as 1877 by Sir William Crookes, but remained for years as little more than interesting phenomena. It was only when television came along with a demand for a light source which would respond instantly to current variations and have a reasonable relation as to light given out for current applied that neon and similar discharge tubes might be said to have come into their own.

In a television receiver a neon tube, so far, is about the only form of electric lamp which will respond with sufficient prompitude and stand up to the tremendously rapid fluctuations applied to it and at the same time fulfil the other conditions mentioned.

Before dealing with the construction of neon tubes, it is just as well to consider how the light is caused.

It must be clearly understood that although a neon tube produces a pink glow when current passes through it, it is not the sort of light which owes its origin to heat, as is the case with the ordinary wire filament lamps in general use.

The phenomenon is due to an entirely different cause, and can take place without any heat whatsoever. The latest scientific theory makes quite an interesting story.



[Photo by courtesy of G.E.C.
Fig. 1.
The plate type of neon tube.

* As everyone knows, bodies are now believed to be composed of atoms, which in their turn consist of a nucleus surrounded by a number of electrons much as the sun is surrounded by the planets. Each electron carries a negative charge of electricity while the nucleus carries a positive charge of sufficient value to balance the combined negative charges of its planetary electrons.

Electrons are not by any means permanently attached to any nucleus; they can be detached, and are equally at home when attached to any nucleus family. They may at times be free and wander in space on their own account. The process of detaching an electron is known as "ionisation," * and an atom which has lost an electron is said to be "ionised."

Of the many methods by which ionisation can take place there is one which is applicable to electric discharges through partially exhausted gases. If a solitary electron is travelling through space at sufficient speed and meets an atom it will either (a) pass through the side of it and neither atom nor electron will be one whit the worse for the meeting, or it may (b) strike or pass very close to an electron belonging to the atom. In the latter case the free electron is deflected from its course, and the atom electron is knocked out of the family group of the atom. This displacement is due to the fact that individual electrons repel one another.†

Cause of the Light.

When such collisions and displacements occur the atom concerned invariably emits light. Probably, under normal conditions, when the free electron has passed away, the displaced electron will rejoin the family group, for during its absence the group which is normally neutral became positive by reason of its absence, and, as the electron carries

* "Story of Chemistry," TELEVISION, July, 1929, p. 252. W. F. F. Shearcroft. Also same author and subject, June, 1929, issue of TELEVISION, p. 201.

* "Photo-electric Currents in Gases." H. Wolfson, TELEVISION, June, 1929. p.171.

† "Radiation—Visible and Invisible," by Dr. J. A. Fleming, TELEVISION, June, 1928, p. 17.

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a negative charge, they naturally attract one another.

This is what takes place in a neon tube when a suitable current is applied. Normally, there are always a few free electrons wandering about in the tube, but their speed is not sufficient to upset any of the atoms of neon present.

As soon as a suitable current is applied to the electrodes, however, the electrons hasten to the positive pole, their speed depending on the strength of the current. In their blind rush they collide with atoms and displace electrons which, finding the attraction of the positive pole much stronger than that of their parent atom, start off on their own account, and in their turn displace other electrons from other atoms, and so the process goes on.

Ionising Action.

At the same time the atoms, deprived of an electron, become positively charged and make their way to the negative pole and can, if their speed is sufficiently great, upset and ionise atoms with which they collide.

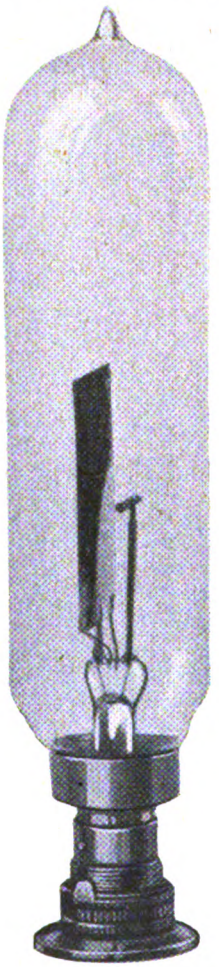
During this turmoil, too, atoms and electrons in suitable positions recombine. When out of this complicated series of movements, *i.e.*, ionisation, recombination and disappearance at the electrodes of such atoms and electrons as reach them, a state of balance is reached, the positions where ionisation and recombination are taking place will not be evenly distributed between the electrodes of the tubes. They alone are the places where a glow is visible, for it is there that the interchange of electrons in their orbits gives rise to ether vibrations which are seen as light. The dark spaces in the tube indicate positions where either the speed of electrons and atoms is too great to give them a chance of recombining under their mutual attraction, or there are only atoms or electrons alone present.

This, in a very broad and general way, is what is taking place in a neon tube or lamp when a current is applied to it, and it is giving out a light.

No mention has been made of the Faraday dark space, the negative glow, the Crookes dark space or the positive column,* because in neon lamps and tubes as used in television work, these regions, although present, have, by the construction of the tube and the gas pressure used, been so accentuated or repressed as to make it difficult for anyone but an expert to identify them all. Subject to this consideration it may, however, be stated that, in a general way, in any tube with a unidirectional current passing through it the positive column will be the source of illumination.

Relation Between Pressure and Glow.

For any given gas and separation of the electrodes there is a definite pressure, usually round about 10 millimetres of mercury, at which the glow can be reproduced with the lowest potential. Increasing the exhaustion beyond this point calls for a higher voltage, as does also a failure to reach the necessary degree of exhaustion.



[*Photo by courtesy of G.E.C.*

Fig. 1A.
Another view of the plate type of neon tube.

In addition to these main factors, however, the starting potential can be considerably varied by the presence of minute quantities of other gases, or the material of which the electrodes are composed. This is taken full advantage of or carefully guarded against in manufacture, as the case may be.

*In the neon tube as used for television or ordinary commercial purposes the electrodes are usually made from nickel or iron. Before assembly they are placed in a vacuum furnace which is pumped out to a low pressure, then the electrodes are raised to red heat so that gases occluded in the metal may be liberated and pumped away. If this were not done, these gases would be freed during the operation of the tube, and so contaminate the gas in which the glow takes place, altering the colour and characteristics of the discharge.

Assembling Tubes.

The vacuum furnaced electrodes are mounted on a " pinch " and sealed into a glass bulb in the usual way, the process resembling that employed in making lamps or valves. In certain tubes, where it is not possible to adopt an electrode system on one support (*e.g.*, where very high voltages are to be applied), the electrodes are sealed individually into the glass envelope by hand, as in the case of the positive column tube, where the electrodes are usually placed one at each end of the tube.

A glass " stemming " tube is sealed into the bulb, so that the discharge tube may be connected to the pumping system. This latter consists of a high-speed mercury vapour pump, capable of exhausting to a pressure of 10^{-6} mms. mercury or less, together with an oven in which the tubes are baked to free the glass of the water vapour and other gases held on and beneath its surface. These, too, would contaminate the tube during life unless removed in manufacture.

Reservoirs of various gases, such as neon, argon, helium, hydrogen, etc., together with purifying devices and pressure gauges, are connected to the pump system, so that the discharge tube may be filled with any gas at any given pressure. Direct and alternating current supplies up to 1,000 volts or more are available for glowing the tubes.

Pumping and Filling.

When the tube has been pumped and baked it is filled with gas at

* "The Neon Lamp in Theory and Practice," by H. Wolfson, TELEVISION, December, 1928, page 40.

* Description of manufacture of neon tubes supplied through the courtesy of G.E.C. Research Laboratory, Wembley.

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about 10 mms. or so pressure, and a heavy discharge passed through it, so that the electrodes are made bright red hot. This frees them of the last traces of occluded gases. The rich red colour of the neon discharge is changed to an intense blue-white by traces of carbon monoxide gas liberated in this way. The contaminated gas is pumped away and the tube refilled to the desired pressure, and sealed off ready for capping.

Of the various types of neon tubes manufactured there are three generally used for television purposes—the plate type, the crater type and the positive column. Of the three, the plate type is most common and is illustrated in Figs. 1 and 1A. The voltage required to operate it, too, is lower than for any of the others.

The whole plate glows and is viewed strip by strip through the scanning disc, which hides all of it except the appropriate portions to be viewed at any instant.

The Crater Type.

In the crater type, Fig. 2, the glow, which, although small in area, is intense, takes place in a small box or tube, the other electrode being arranged as a metal ring around it.

The crater type of neon lamp is only suitable for use in television systems employing an optical system, to project the point of light on to a screen and make it sweep over the whole area of the picture.

In the positive column type of tube, which looks very like an ordinary vacuum tube used for demonstration purposes with a sparking coil, the whole of the tube glows with a bright red light. A fairly high voltage is required to operate it, and so far it has only been used in television systems similar to that using the crater type of tube, or for colour television, where its freedom from electrodes makes it suitable because another tube or tubes can be viewed through it.

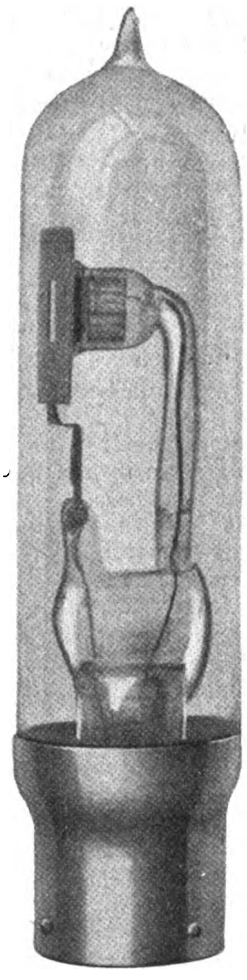
In addition to its ability to respond fairly accurately to rapid current fluctuations, a neon tube can be used to detect very minute quantities of current, providing the voltage is high enough—most wireless amateurs are fully conversant with it as an indicator in a wave-meter. It can also be used as a rectifier of current and as a generator of oscillations.

Neon as Oscillograph.

There is, however, another use to which it can be put. When fitted up behind a scanning disc, a neon tube can act as an oscillograph. By reason of the rotation of the scanning disc it does not give an image of loops or curves such as are obtained from a cathode ray oscillograph, but, instead, a pattern of wavy lines or dots of various sizes is seen.

These patterns bear a definite relation as to size of line and general arrangement to the electrical signal causing them.

Any amateur can test this for himself by making a scanning disc—size



[*Photo by courtesy of G.E.C.*

Fig. 2.
The crater type of neon tube.

and number of holes are not material—and fitting it with a neon behind and a fairly good motor which will rotate the disc at a suitable steady speed — synchronisation does not matter. If the neon is then used instead of the loud-speaker for the reception of the local station broadcast, a constantly changing pattern will be seen when it is viewed through the holes of the rotating disc, heavy broad dark lines representing loud sounds, and fine wriggly dark and light lines showing for the higher notes and faint sounds.

Detaching the aerial and the earth from the wireless set and moving the reaction control well away from the oscillation point will show whether the low frequency or high frequency sides of the set are stable and free from oscillation.

The faintest suggestion of a pattern indicates oscillation, whether it be audible or not, and it can be taken as a general rule that fine light and dark lines represent high frequency notes while broad dark lines will be low frequency notes.

With this as a guide, the effect of various adjustments can be tried until no pattern is visible. This exercise, too, will be a useful experiment, for when "televisors" are available the wireless set will have to be adjusted until there is no oscillation present if true, undistorted images are to be seen.

The Literature of Television

(*Concluded from page* 348.)

Personally, however, the writer employs a system of notebooks for his own work on each subject, and special books in which references to articles of interest to him in each line are entered as he comes across them.

The difficulty is to avoid the references becoming useless due to the impossibility of finding the one desired in a reasonable time. Alphabetical indexes of either authors or titles do not always give the information required to turn up an imperfectly remembered reference, and make it a heart-rending task to find all the information available on, say, a minor branch of the subject in hand. Then, too, there is the bother of entering each item in the correct index and so few titles really explain the scope of the articles they refer to.

A compromise which has passed the acid test of use for some time is illustrated on Fig. 1. Here a folio of the author's television reference notebook is shown. The system of subdividing the references into columns and writing the titles and authors in in capital letters has made it possible for one to flick over the leaves and find the information required in a very short time.

The titles are not necessarily the original ones, but are modified to describe the references correctly.

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Sydney A. Moseley

ON

The New Offer to Baird

AS I gave readers of the TELEVISION magazine every encouragement to believe, a new offer of broadcasting facilities has been made to the Baird Television Company by the Postmaster-General.

Whatever official announcement may be made on the subject, it is due to my readers to know that *this new offer is a direct result of the visit of the Postmaster-General himself to the Baird studios in Long Acre.*

You may recollect that in my article referring to Mr. Lees-Smith, with whom I had the privilege of over an hour's conversation in discussing the situation, I described him as:

> "A conscientious and painstaking man. The public will not forget the impression of independence and clear-thinking which he gave during the course of the protracted Savage enquiry. I have reason to know that the qualities which marked him out as a man of unusual strength of character are being brought to bear upon the present problem. He himself has called for the papers (and they are voluminous), and is giving them particular study."

That description was not exaggerated, for he came to see for himself, examined the prejudices from all sides, and, despite the obvious pressure that must have been brought to bear from forces hostile to Baird interests, *he decided that what he saw was sufficiently good to warrant an offer on a far more generous scale than that offered directly by the B.B.C. to the Baird Company.*

Even the friends of Savoy Hill regarded their offer of three separate quarters of an hour per week as frivolous, but it was not only frivolous but foolish, for it betrayed the spirit of unfriendliness which has been so marked throughout the entire history of this unhappy controversy..

Make no mistake about the matter; I repeat: this new offer of five half-hours per week is not due to a generous gesture by the B.B.C., but is a direct result of the visit of the Postmaster-General and a technical adviser from the G.P.O.

Whether the Baird Company will consider even this offer sufficiently adequate, in view of the strides it has made, not only on the technical side but in impressing the public of its claims upon the Government, remains to be seen.

My own advice has been that it should accept this offer *only as a beginning*, and *under certain obvious conditions* that ought to be attached to the acceptance.

Naturally a company that is of such public importance must protect itself against actions unfavourable to its interests which may be advocated by those members of the B.B.C. who are so conscious of their monopoly as to attempt to deny the elements of justice to the pioneers of a new science.

There is no doubt, and readers should be prepared for this, that even now the road is not clear.

It is put to me very forcibly from a quarter to which I have every reason to pay attention that opposition to television is still as strong as ever. The enemy may have had a setback here, and they may be discouraged by these latest developments, *but they are by no means dismayed.*

A corner of the Baird Laboratories in North London.

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The tendency would appear to be to dabble with foreign claimants to television, so that the issue shall be confused, and that the rights of the Baird Company shall be eclipsed, if not submerged, by false issues.

Obviously, the progress of the Baird invention is such that before very long it may claim a vast measure of popularity on the part of listeners.

If, for instance, within a year or so, two hundred thousand or more listeners will look-in, as well as listen-in, the Baird Company would have the right to claim part of the licence fee.

This is what the B.B.C. appears to fear. They desire to retain the whole of the licence fee. It is not so much that they are not now convinced of the commercial utility of television, but they fear this potent rival over which they have no control.

Now, if the B.B.C. could only control television—ah ! that would be another matter.

I suggest that readers of this magazine, and my friends in Parliament, pay heed to this continued opposition which goes on behind the scenes. Do not be surprised if some foreign inventor, camouflaged under the name of "British finance," appears in this country and is brought into prominence by friends of the B.B.C., in much the same way as Wireless Pictures was brought to the notice of the public and intending investors.

I warned readers what would happen to Wireless Pictures, and of the grave error of public policy on the part of the British Broadcasting Corporation in permitting their name to appear in a public prospectus, and I now warn readers again that attempts may be made to foist on them a rival foreign inventor, so that Mr. Baird in the end shall be cheated out of his full due, and, particularly, that the B.B.C. may in this way retain its monopolistic powers, which is this case at any rate have been misused.

These forces fail to take into account the rising tide of hostile public opinion. The average man in the street who may know little about television knows at any rate that Mr. Baird has not had a fair deal.

Just as we have revealed these attempts to suppress television in the past, so shall we continue to fight until full victory, now in sight, shall be beyond all possible dispute or danger.

Talking Films by Television

ONCE again Mr. J. L. Baird, the British television inventor, has established a lead over his rivals in other lands by giving recently the first public demonstration of the transmission by television of talking films. An account of this demonstration appeared in the *Times* of August 20th.

Mr. Baird, himself, experimented successfully with the transmission of ordinary silent films some years ago, and since then one or two foreign experimenters, notably C. F. Jenkins, in America, have conducted successful experimental transmissions of specially made silhouette films. In the recent Baird experiments ordinary standard talking films were used.

The Baird Company found that the transmissions of cinematograph films, although simpler than television had very little interest, and concentrated their attention upon television proper, but lately a new advance has been made in the Baird laboratories, which has brought telecinema into the position where it will form a valuable adjunct to television. By using a speaking film, and combining the broadcasting of sound with the broadcasting of the film image, the Baird Company have been able to broadcast speaking films.

The tele-talking film, or to give it the name which has been coined for it by Baird, "Tele-talkie," has an interest value of its own. By this means films such as are used by the big speaking film Corporations can be sent out over the ether in the same way as television, and received on the standard "televisor," so that programmes may be alternated—the actual person being seen and heard for one turn, and a "tele-talkie" for another turn.

The importance of sending speech with vision is immensely accentuated where "tele-talkies" are concerned, because, owing to the fact that only a 9-kilocycle broadcast waveband can be used, both television and tele-talkies are at present limited to somewhat restricted scenes, (if fine detail is to be given) such as one or two persons speaking or singing; and such subjects when *seen* only, without their accompanying sounds, have very little interest, compared with a combination of vision and sound, as shown by the "tele-talkie." The sound helps the vision, and vision helps the sound, and the combination is infinitely superior to one or the other separately.

The technical side is simple enough in its operation, and is described elsewhere in this issue.

The public demonstration was in every way a success. The film shown was a head and shoulders view of George Robey giving a monologue. It was not a silhouette film; normal shading and detail were clearly visible, and one got the impression of looking at a small amateur film on a miniature screen. The reproduction of the voice was excellent.

The Television programmes first sent out will consist chiefly of television proper, which is, of course, the most interesting—that is to say, the transmission of actual persons as they sit in front of the microphone, so that the audience can see on the screen of their televisors, and hear the person who is broadcasting from the studio; but as at present in sound broadcasting, gramophone records are occasionally played, so also will television programmes be supplemented by the occasional transmission of tele-talkies.

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THE NATIONAL RADIO EXHIBITION
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September 23rd to October 3rd, 1929

You will find TELEVISION this year on the Balcony at Stand 241, the first Stand on the left as you walk up the Grand Staircase.

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Baird Television
AS SEEN BY A DUTCHMAN

THE Editor of TELEVISION has asked me to write an article on my impressions of the Baird Television demonstrations, to which request I am glad to acquiesce.

It was in the middle of last year that I met with television first. As the readers of TELEVISION will probably know, a large exhibition, the "Nenyto," was held in Rotterdam. I was walking about, looking at the various articles exhibited, when I was suddenly attracted by a peculiar machine, standing on a desk, consisting of various disks, a motor, etc. I did not understand a bit of it, and, being always interested in all scientific apparatus, I went to it, and there made my first acquaintance with Mr. William C. Fox, one of the staff of the Baird International Television Company. He explained things to me, and the whole attracted me very much.

This first chat was followed by others, and I got so interested that I wanted to make such a piece of apparatus myself. I say, make it myself, for being an enthusiastic wireless amateur of the old days, I do not like to buy things ready made, but like it far better to build them myself. As, however, Mr. Baird was still experimenting to improve his system, I could not get the components necessary for a television receiver.

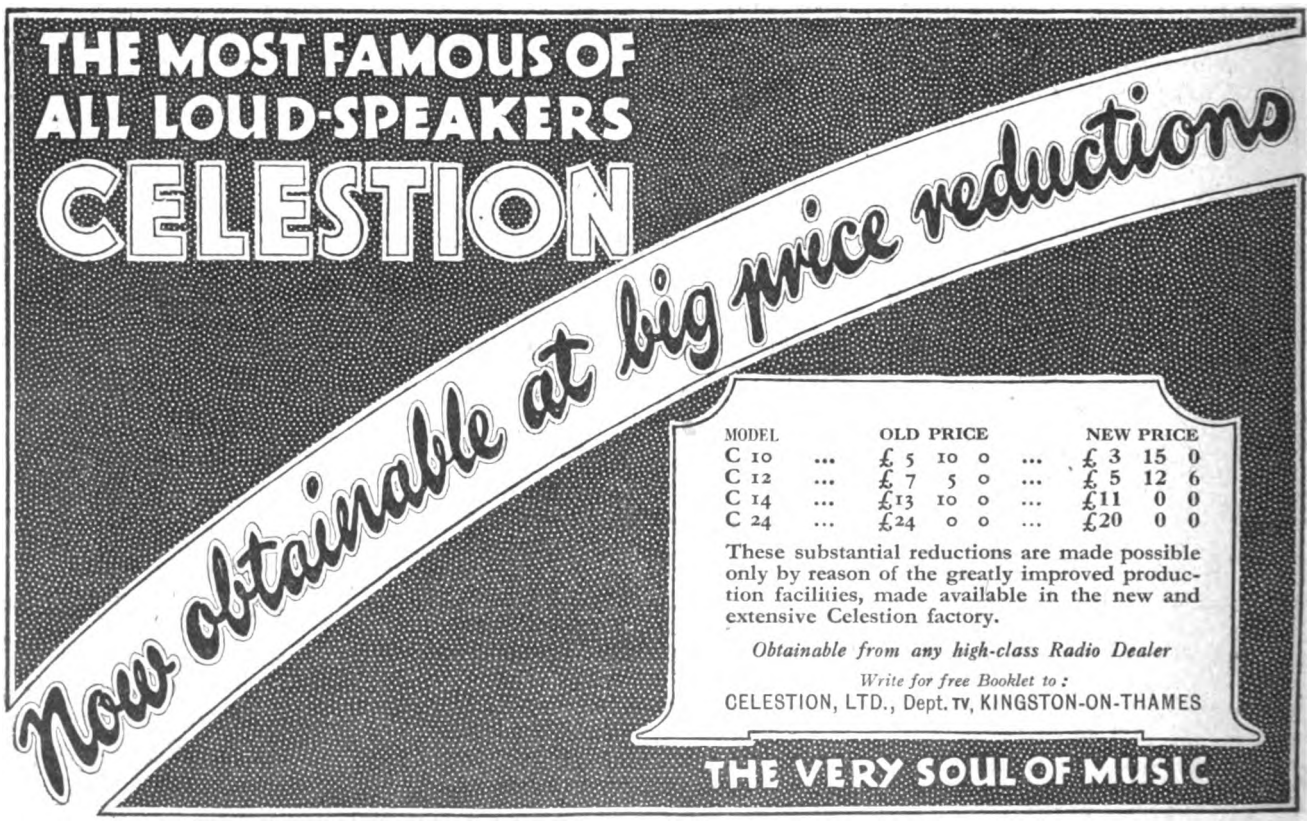
Many people visited the television stand in Rotterdam, and what they all asked for was a "demonstration," which we had at last, just before the exhibition closed down. This demonstration gave me the final touch. Although the equipment was quite experimental, the results obtained were very good, and many leading personalities in Holland, among others the Dutch Prince, visited the stand, and were highly satisfied by the results they saw.

I then did not see much of television until our wireless exhibition was held in Scheveningen, some weeks ago. Here the Telefunken Televisor, of Professor Karolus, of Berlin, was shown, and on a Sunday morning I went to Scheveningen, to see the exhibition, and to have this system demonstrated to me. The results obtained were quite good, although in my opinion the results obtained by Mr. Baird the year before in Rotterdam were still better.

Being in London for my holidays this month, I of course called upon the Baird Company to see and hear a demonstration of their latest apparatus. I came, saw and was convinced that this was real television, ready to be broadcast. A friend who was with me was placed before the transmitter, and I could see him and recognise every detail, as if I was looking at him through a small window. It struck me that the receiving apparatus was very simple to tune. Only a few knobs, etc., nothing else. I wonder how Mr. Baird has solved the synchronising; this is really wonderful, and needs no adjustment whatever.

I have heard about the difficulties which the Baird Co. has experienced in getting their apparatus installed at one of the transmitters of the B.B.C. I hope these difficulties will be solved shortly, so that at last we will have real television daily over one of the B.B.C. stations.

J. W. A. VAN SCHIE.



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The Television Society

PROGRESS ABROAD.
NEGOTIATIONS with THE B.B.C.
WINTER PROGRAMME.

NEWS has just come to hand of the Inaugural Meeting of the French Television Society which took place on May 30th. We should like to take this opportunity of wishing the French Society a long and useful life and trust we shall hear more of its activities later on.

French Television Society.

The First Annual General Meeting was held under the chairmanship of Monsieur Edouard Belin, the President. Resolutions confirming the constitution of the Society were passed and the following gentlemen were invited to become honorary members :—

Messrs. Branly, Chevallier, Dauvillier, General Ferrié, Messrs. Holweck, Lumiere, Valensi. The following appointments and office bearers were confirmed :—President, Monsieur E. Belin. Vice-Presidents, Col. Cornu and Beauvais. General Secretary, Jacques de Coucy. Under-Secretaries, Messrs. Aisburg Toulon and R. Thiellement. Treasurer, G. Thiellement. Administrative Officials, Messrs. Abadie, Bouthillon, Duc. de Broglie, Brylinski, General Cartier, Messrs. Chiron David, General Delcambre, Col. Deve, Messrs. Fabry, Imba, Col. Julien, Messrs. Charles Laurent Leuate, Lecornu, Mesny, Routin de Balbreuse.

Messrs. Joly Leveque Guillain, chartered accountants, were elected auditors for the year 1929.

The President then delivered a speech which is summarised :—

" Gentlemen,

" Our meeting to-day is the realisation of a bold idea.

" From now on we should associate the idea of the foundation of this Society, so characteristic of an era of big technical advancements, with the names of those who have conceived the original scheme and planned its realisation, namely, Messrs. Aisberg and Chiron.

" At this stage, we might well cast our minds back over the past 50 years and recall the numerous inventors who have attempted to solve the problem of transmitting a living image to a distance. They may have been attracted to this research because of its difficulty. But how many attempts have been planned with enthusiasm and then abandoned in despair.

M. EDOUARD BELIN.
President of the newly founded French Television Society.

" Those early attempts were not successful because the scientific means at the disposal of the workers were insufficient. In addition, ridicule and even scepticism have caused discouragement.

" Of those present this evening, I am myself perhaps best qualified to know the very great difficulties and also the disillusions. So that it is with real emotion that I see founded to-day a society under the patronage of men of whom French Science is proud, and among whom are such names as those of General Ferrié and Mons. Lumiere whom we are specially proud to welcome. We are gathered here, gentlemen, with the firm desire to see the advancement of the French Television Society and we thank those eminent and learned men who honour us with their presence.

" We welcome as well the members of our Honorary Committee and all the high personalities who have been good enough to accept office on our Board of Administration.

" After having been considered as an utopia for such a long time, the solution of the problem of television has now become a reality. Can we say that the task of the technical experts is finished ? Certainly not ; now we begin to see the real basis of progress evolving from the mystery which has hitherto surrounded television, and so the problem begins to fix itself and thus deserves a methodical study on the part of learned and practical men. Various methods of solution are, as you know, proposed, and without wishing in any way to minimise the value of methods used in other countries, we have the right, even the duty, to make known that in France, very important work has been done already which is leading to practical results and this reason justifies the foundation of this Society in a country which has always been in the front rank of inventions.

" All that has so far been acquired in the way of development must be perfected, and at the same time other problems must be studied and

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experimented with. But in order to do so the technical difficulties should not be known only by a few. All minds interested in progress should be enabled to contribute to the general efforts. This collaboration can exist by the founding of an association which has this principle as its leading motive. Our task, gentlemen, is not only to work for ourselves, but to attract to the study —which is so captivating— not only those who by their special studies are destined to science, but also those young men who are anxious to taste of scientific achievement, and there are many of those young men filled with the enthusiasm for discovery.

"The founders of this society have on good grounds not wished to limit its activities solely to television, and they have extended the field of their activities to the transmission of pictures. Both subjects, as well as the talking-film, depend on photo-electricity, a comparatively new branch of science. But all these problems are so interlaced with each other that their study should logically be considered as belonging to the same domain.

"The task before our Society is thus very great, and I ask myself whether I am not undertaking a too great a burden.

"Gentlemen, you have conferred on me a great honour and I am touched by it and very proud too. I will do my best to deserve your confidence, and I will endeavour to do it with that enthusiasm that I have hitherto shown for this research, so that I hope our gathering to-day will go down in history as a date of importance."

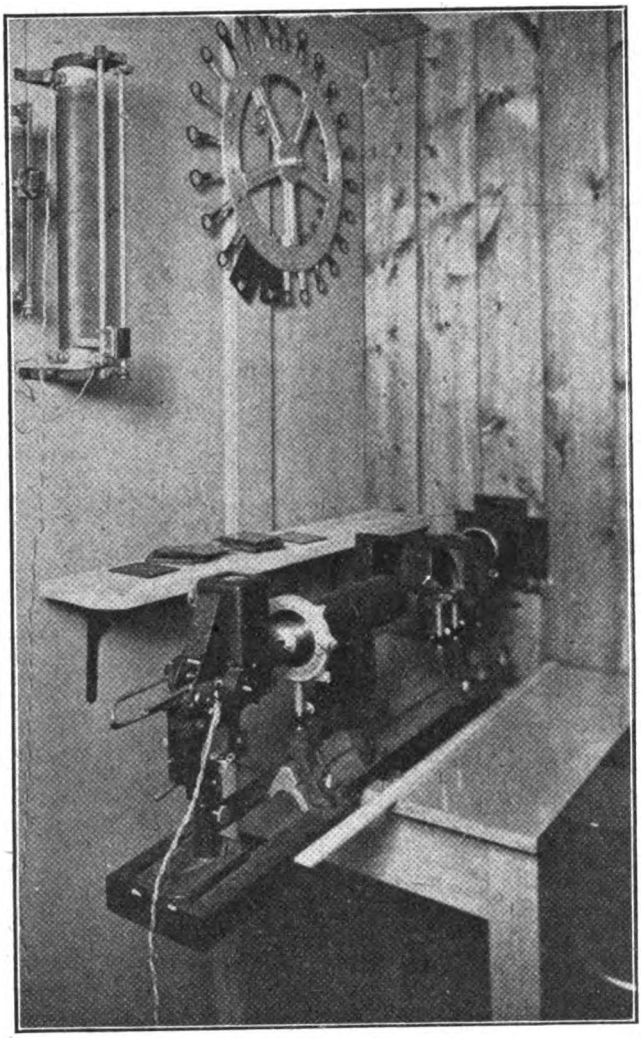
* * *

The Council of the Television Society has always had in mind, from its inception, the "International aspect" of television, for it is "International" ether which forms the link between transmitter and receiver. A letter has accordingly been sent to the French Society wishing it success, and expressing the hope that the closest co-operation between the two bodies may result.

* * *

News from South Africa.

Dr. Clarence Tierney, F.R.M.S., our Chairman, gave a talk from the Capetown broadcasting station on July 24th.



This photograph shows the transmitter with which Captain R. Wilson, Member of the Council of the Television Society, is at present televising ordinary lantern slides and films. He writes :

"These are sent by land-line to the other side of my house and are received clearly with natural shading. With a modified arrangement of this transmitter good results of television by reflected light have just been obtained."

Some of the apparatus and methods used by Captain Wilson are being described month by month in these pages by his collaborator, Mr. A. A. Waters.

Abstract of Correspondence between the Television Society and the Baird Television Development Company.

17th July, 1929.

THE SECRETARY,
The Baird Television
Development Co., Ltd.,
133, Long Acre, W.C. 2.

DEAR SIR,

With reference to the negotiations with the B.B.C. for broadcast facilities of Television, it would be of interest to members of the above Society if you could kindly state the present position or future prospects of this service.

I am,
Yours faithfully,
WM. C. KEAY,
Deputy Chairman of Council.

July 31st, 1929.

WM. C. KEAY, Esq.,
The Television Society,
4, Duke Street,
Adelphi, W.C. 2.

DEAR MR. KEAY,

I am sorry that it has not been possible to reply to your letter before. Yesterday I had an opportunity of discussing the matter with Captain Hutchinson and he has asked me to reply fully to your letter. To explain the present position regarding broadcasting, I must take you back to March last.

You will remember that in that month we gave a demonstration by wireless from 2LO to the late Postmaster - General, Sir William Mitchell Thomson, and a specially selected deputation of Members of Parliament, all non-technical and representative of public opinion. The demonstration was also given to the Post Office engineers and the British Broadcasting Corporation's governors and engineers. Following that demonstration the late Postmaster-General sent to us his letter of March 27th last, the terms of which will be in your mind, but I particularly want to remind you of the passage where the Postmaster-General stated that he was anxious that facilities should be afforded so far as was practicable without impairing the broadcasting service, for continued and progressive experiments with the Baird apparatus and that he would assent to a station of the British Broadcasting Corporation being utilised for this purpose outside broadcasting hours.

Negotiations took place with the British Broadcasting Corporation and at a final interview with Mr. Baird

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and Captain Hutchinson which took place with Captain Eckersley, the chief engineer, times of broadcasting were agreed with Captain Eckersley.

. . . . .

On June 26th we received a letter from the British Broadcasting Corporation offering us facilities of three periods per week of one quarter of an hour each and also imposing many conditions, the chief one of which was that we could be stopped from broadcasting at any moment. This was the interpretation placed by the British Broadcasting Corporation on the expressed wish of the Postmaster-General that we should be afforded facilities for "continued and progressive experiments."

The offer was considered by the Board and the only course possible was agreed. That was to inform the British Broadcasting Corporation that their offer was totally inadequate and that we were again taking up the matter with the Postmaster-General and taking such other steps as we might be legally advised. This has been done and I may say that the Postmaster-General is giving the matter his most sympathetic consideration. Up to the present time no intimation has been given to us of the decision of the Postmaster-General. I will, however, let you hear from me again as soon as we hear of any such decision.

Yours faithfully,

(Signed) T. W. BARTLETT,
Secretary.

Baird Tevision Development
Company, Limited,
133, Long Acre,
W.C. 2.

August 20th. 1929.

W. C. KEAY, Esq.,
Deputy Chairman,
The Television Society,
4, Duke Street,
Adelphi, W.C. 2.

DEAR SIR,

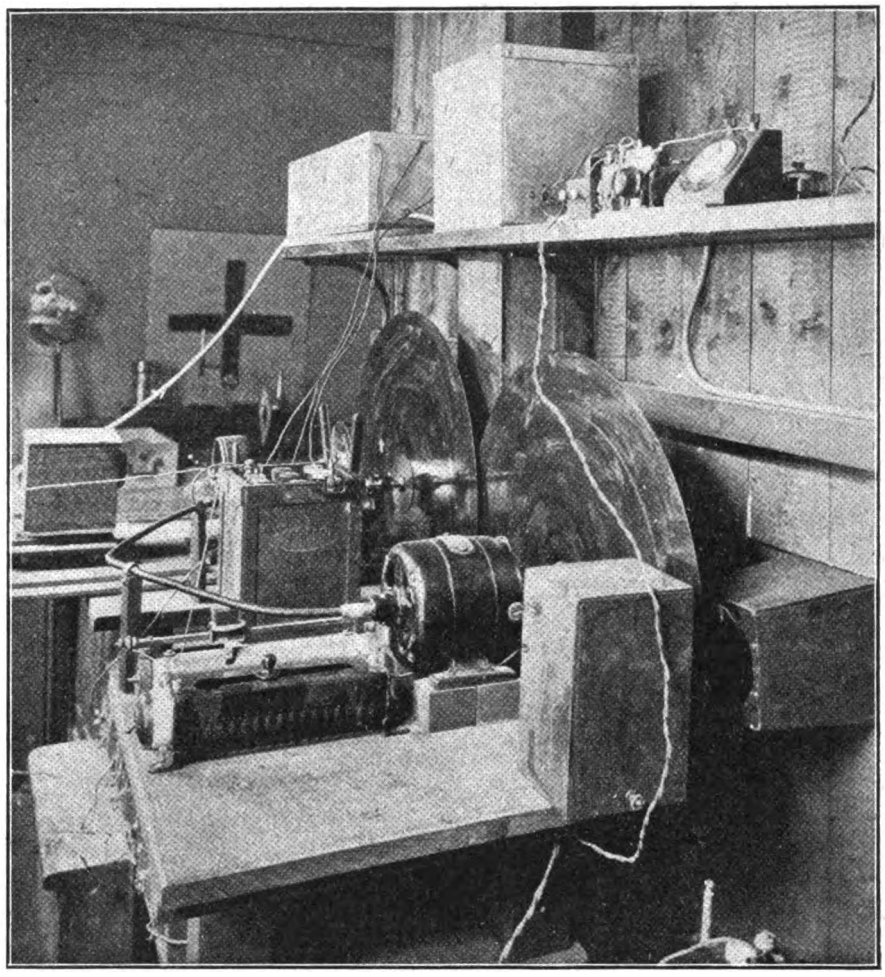
Following upon our letter of the 31st ult., I now beg to inform you that we have received a communication from the Postmaster-General stating that he has been in consultation with the British Broadcasting Corporation regarding facilities for broadcasting television and at his request extended facilities from three periods of one-quarter of an hour per week, as previously offered, to five periods of a half-hour each per week have now been offered us.

We have acknowledged this letter and the offer is now under consideration by the directors. A copy of our reply will be forwarded to you in due course.

Yours faithfully,

O. G. HUTCHINSON,
Managing Director.

Baird Television Development
Company, Limited,
133, Long Acre,
W.C. 2.



Rear view of Captain Wilson's transmitter, showing also the pilot receiver and amplifiers.

Lectures arranged October 1st, 1929, to January 7th, 1930.

The following lectures will be given at The Engineers' Club, Coventry Street, London, W.C. 2, during the forthcoming session :—

TUESDAY, October 1st, 8 p.m.—H. S. Ryland (Fellow, Optical Society) : "Talking Films" (with demonstration).

TUESDAY, November 5th, 8 p.m.—F. Langforth-Smith, B.Sc., B.Eng. : "Amplification and Television" (with experiments).

TUESDAY, December 3rd, 8 p.m.—G. Priechenfried, Esq. : "The problem of Synchronisation in Picture Transmission and Television" (slides).

TUESDAY, January 7th, 8 p.m.—E. George Lewin, M.Sc. A.Inst.P. : "Television — Some Suggested Schemes" (slides).

Suggestions from members will be welcomed regarding subjects for discussion at the informal meeting held for one hour before the lecture each evening.

Members who have not paid their subscription to the Society since January 1st, 1929, are requested to kindly remit to headquarters.

The secretaries are now busy with their plans for perfecting the arrangements so that members may look

(*Continued on page* 363.)

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The Practical Evolution of the Photo-Electric Cell

By H. WOLFSON

WITHIN the last few years the photo-electric cell has come to be recognised as one of the most important of modern scientific devices. The use of photo-electric cells in television is the one which naturally interests us most, though the same type of cell can be used in devices for automatic colour matching, photometry, and sound films, to mention but a few things which depend on the action of light in some way or other.

We have previously considered the theoretical side of the subject, and it is my intention to give my readers, in this article, some idea of how the theoretical results have been applied in practice to the design and construction of photo-electric cells.

The Simplest Form.

One of the simplest forms of cell was designed by Elster and Geitel in 1910, and consisted of a spherical glass vessel, which was silvered inside in those parts where it was desired to deposit the sensitive substance. This cell is illustrated in Fig. 1. The silvering of the interior of the cell can be accomplished in a number of ways, though perhaps the simplest method consists of filling the cell with silvering solution, such as is employed in ordinary commercial practice for the silvering of mirrors. Heat is then applied, very gently, to those parts where the deposit is desired. The next step, which consists in the drying of the vessel, need not be described in detail. When all ordinary drying methods have been employed, it is usual to " bake " the vessel at about 350° C for a considerable time, in order to remove not only the last traces of moisture, but also any gas which may be, and invariably is, occluded by the glass and the silvering.

The next step is to seal in the electrodes, and this is an operation which requires great care, owing to the liability of the glass to crack. For this reason it is now more usual to seal in the electrodes before the silvering is undertaken.

Pure redistilled potassium or other alkali metal must now be introduced into the cell. This can be done in a variety of ways. The method adopted in the case of these earlier workers was to distil the metal, first carefully purified, by multiple redis-

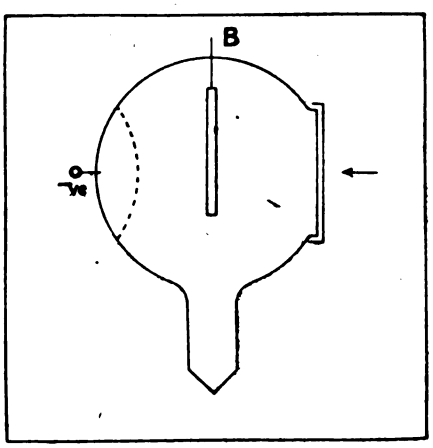

Fig. 1.—Elster and Geitel Cell.

tillation, into a side tube attached to the bulb, the whole of the cell being evacuated the while by means of a Gaede vacuum pump. When the cell is filled to the requisite amount the side tube is carefully sealed off by means of the blowpipe flame. This operation, though decidedly tricky to an amateur, presents no difficulty to an experienced glass-blower.

Vacuum or Gasfilled Cells.

One must now decide whether it is desired to finish up with a vacuum or gasfilled cell. If the former is required, the evacuation, up to this stage carried on by the Gaede pump, is completed by means of a Langmuir mercury pump. This produces vacua which are well-nigh perfect.

If one wishes for a gasfilled cell, the vacuum pump is cut off, and, by means of a three-way tap, a supply of chemically pure hydrogen is admitted to the cell. The vacuum pump is then set going again, and the cell exhausted of hydrogen. More hydrogen is admitted, and the pressure is again reduced by means of the pump. This time, since complete evacuation is not aimed at, the pump is stopped when the requisite pressure of hydrogen has been attained. This pressure is so chosen that a low pressure discharge can be sustained in the cell. The alkali metal is made the cathode in this hydrogen glow-discharge, and by this means the formation of collodial alkali metal hydride is induced. This has the effect of increasing many times the sensitivity of the alkali metal. The appearance of the normally colourless metal after this treatment is blue-violet in the case of potassium, and may vary from green to blue in the case of the other alkali metals, with the exception of sodium, which gives a brown colour after this treatment.

How Gas is Introduced.

The cell is once more connected to the vacuum pump, and all the hydrogen removed. Then, in a similar manner to that just described for filling with hydrogen, some inert gas, such as helium or argon, is admitted to the cell at low pressure, and the cell is finally sealed off. It should be noted that after the Gaede pump is first connected the cell is never open to the outside air, all subsequent operations being carried out with the aid of a three-way glass tap, by which any other apparatus, such as pumps or gasholders, can be connected with the cell. A current of

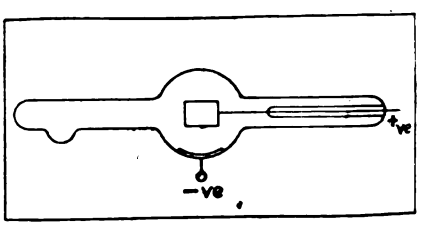

Fig. 2.—Schulz Photo Cell.

four micro-ampères can be obtained from cells of the Elster-Geitel type, *i.e.*, containing potassium hydride, when the source of illumination is feeble sunlight.

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In the cell illustrated in Fig. 1 it will be noted that an additional electrode, B, has been added. This auxiliary electrode is used for

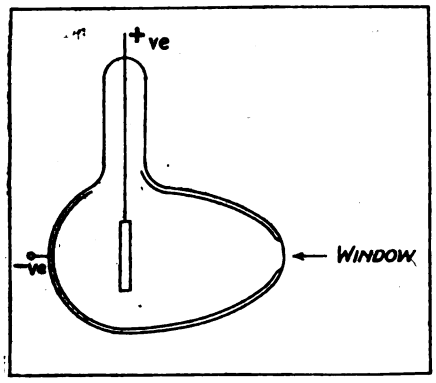

Fig. 3.—The Hughes' Type Cell.

applying an accelerating potential difference, so that the photo-electrons may be driven across the cell.

Proportional Response.

With this type of cell Elster and Geitel found that the photo-current was proportional to the intensity of illumination over even a greater range than that which was investigated by Richtmeyer.* In very intense sunlight, however, the response may not be proportional to the light intensity, and currents of one milliampere may be produced with accelerating potentials as low as 20 volts. In such a case it would be safer to employ a vacuum cell, where the current is many times smaller, or, alternatively, recourse may be had to a diaphragm, with which to stop down the light. The minimum amount of light which affects such a cell is of the order of 10^{-7} erg/sec.cm.^{2}, this amount of energy producing a current of about 10^{-15} amp. That means to say that an amount of energy which corresponds to only (about) 300,000 quanta of energy, assuming an average figure for the visible spectrum, will produce a current of one thousand millionth of a micro-ampère. This current is not measured directly, of course, but is computed from measurements indirectly dependent upon it.

The cell of Schulz, which was designed primarily to measure the light intensity from stars, has a differently shaped containing vessel to that already described. Fig. 2 gives a good idea of the cell. The anode is a platinum wire, 0·5 mm. in diameter, bent into a rectangular loop measuring 1 by 1½ cm., the connection to the outside, passing through a glass sleeve, being about four centimetres long. The layer of potassium is deposited on the wall of the cell facing the plane of this loop. Contact was made with this layer of sensitive metal by means of a sealed-in platinum wire which made contact with a layer of silver, as in the cell already described. The bulb of the cell was 5 cm. in diameter, *i.e.*, about two inches, and the potassium is placed first in the depression shown in one limb of the bulb, whence it is afterwards distilled. The metal was activated by the Elster and Geitel method, and the cell was afterwards filled with helium, the pressure of which was adjusted before the cell was finally sealed off, so that the current given by the cell was a maximum.

According to Kemp, who has carefully studied the conditions for maximum sensitiveness, a potassium cell containing hydrogen is about one hundred times as sensitive after the formation of the hydride than before. The electrodes should not be more than 0·5 cm. apart, and the pressure of the hydrogen at 25° C. should be kept within 2—3 mm. The accelerating potential under these conditions is 330 volts.

Hughes designed a cell, about 1913, which resembles the so-called black body enclosures, such as are used in the study of heat radiation. The vessel containing the alkali metal is a pear-shaped glass flask, provided with a quartz window (Fig. 3). The inside is first silvered in the usual manner. The sodium is then distilled on to the inner surface of the vessel, care being taken that no sodium deposits on the quartz window, through which the light enters. By the use of a vessel of this shape the light, after entering, is reflected many times from the bright surface of the alkali metal, the net result being that, after successive multiple reflections, almost all of the light is " trapped " by the photo-sensitive surface. Using light isolated from the violet end of the spectrum, and having a wavelength of 436$\mu\mu$, Hughes obtained a current of 580×10^{-11} ampères.

False Currents.

About the same time as Hughes was producing this improved type of cell, Elster and Geitel in Germany, and Ives in America, had begun to realise that cells with which they had been working so far suffered from a rather serious defect. This was that a current existed in the cells even when they were in the dark. In reality, they found that there were two false currents, which acted in opposite directions.

The first of these spurious currents is ascribed to contact difference of potential, and is opposite in direction to the photo-electric current. The second, called the " dark " current, is doubtless the result of current conduction over the surface of the glass containing vessel. The remedy which suggests itself is to choose the glass for the cell with the utmost care, so as to obtain high insulating properties. The difficulty can be overcome to some extent, also, by separating the electrodes as far as possible. In many cells, which are of small dimensions, this latter method does not give by any means complete freedom from " dark " current.

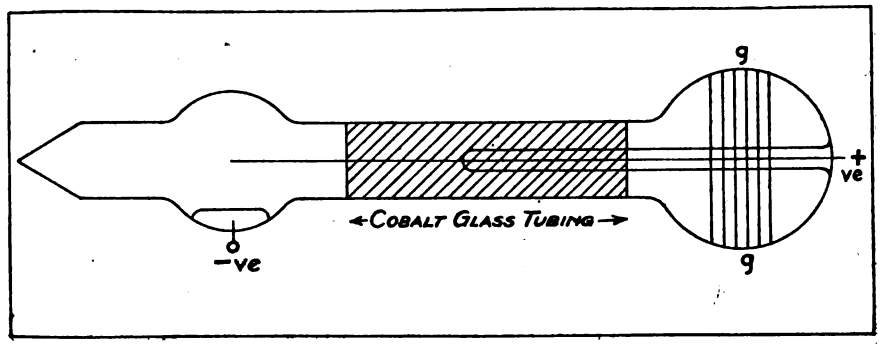

Fig. 4.—Ives' Cell. Note highly insulating cobalt glass insert and guard rings, GG.

Fig. 4 illustrates a form of cell designed to overcome the difficulty in a manner well known in electrostatics. The cell is provided with internal and external guard rings (*g*), which are earth connected when the cell is in use. Almost complete protection is afforded by this method,

* TELEVISION, Nov., 1928, p. 52.

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as the stray currents are allowed to leak away to earth, and do not interfere with the normal working of the cell. A piece of cobalt glass tube

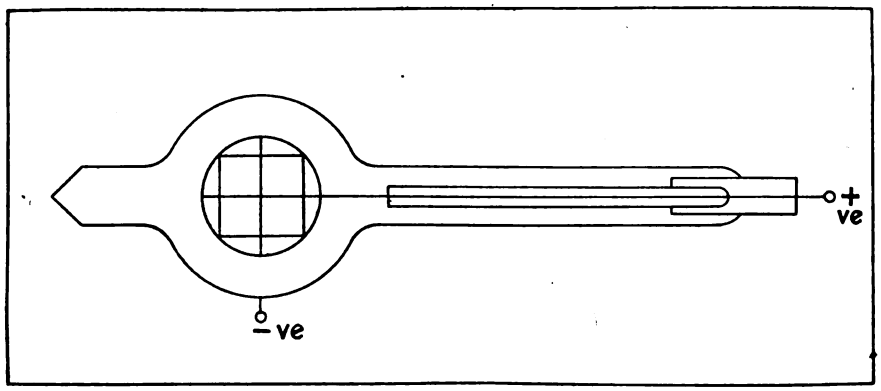

Fig. 5.—Kunz Cell.

of very high electrical resistance is fused into the cell at *c* and this forms an additional protection.

Working with cells in which the pressure of residual gas was not more than $7{\cdot}5 \times 10^{-7}$ mm. of mercury, Ives, Dushman and Karrer found that although the irregularities present in gasfilled cells were not present, the relationship between light intensity and photo-current was not rectilinear. This non-rectilinearity was finally traced to what has been termed "focussing effects." By this term is implied a change in direction of the electron stream with the *number* of electrons emitted. The result of the changing directions is that a varying proportion of the total number of emitted electrons reaches the anode or receiving electrode. A satisfactory explanation of this phenomenon has been found by assuming the presence of electro-static fields, which, varying with the strength of the photo-electric current, change the "focus" of the stream of photo-electrons.

A cell was constructed which gives true rectilinear relation between the intensity of illumination and the photo-electric current. A 10 cm. glass bulb, silvered on the inside, is provided with a side tube, which carries a small window. The silvered surface is, in this case, used a the anode, while the cathode is a small centrally placed silvered glass bulb, on to the surface of which is distilled the active alkali metal. In this way the cell had no *free* surfaces to collect stray charges.

In Fig. 5 is illustrated the cell developed by Kunz. It is constructed of either glass or quartz, and the central bulb is only about 3·5 cm. in diameter. The inside of the bulb is silvered, and the alkali metal distilled on to this surface. Contact is made with the silvered surface by means of a sealed-in platinum wire. The anode is a grid formed of platinum wire, and in order to prevent undue leakage is surrounded by a long glass tube. Further improvement is effected by surrounding this tube by a platinum cylinder, which can either be earthed or maintained at a definite potential. For the alkali metal Kunz found that rubidium gave very good results, and in cells of the gasfilled type he used neon at a suitable pressure. The difficulty of dark current, so common in this type of cell, was overcome by allowing the alkali metal to cover all but a very small portion of the cell, so that a very small hole only was left for the light to enter. The provision of a gauze or network anode, as mentioned, helps considerably towards eliminating the dark current.

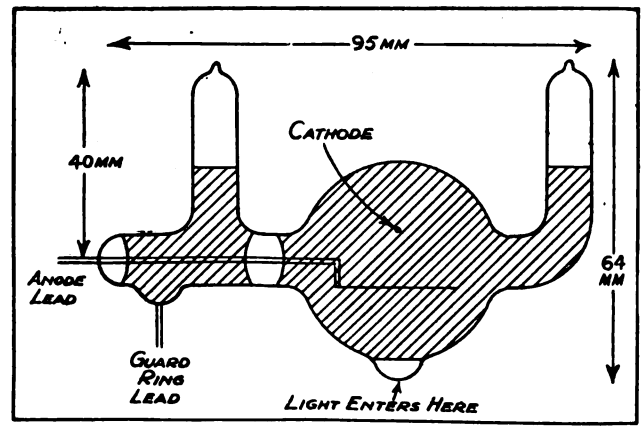

Fig. 6.—G.E.C. Experimental Cell of 1924. Shading denotes silvering.

An interesting departure from the more or less standard practice of filling the cells by a process of distillation is found in Zworykin's method. This is what might be termed an electrolytic process. The cell is constructed of a similar form to ordinary cells, the electrodes being sealed into the glass. The wire which, in the finished cell, will constitute the anode, has both its free ends led out through the glass. The cell is then evacuated or gasfilled, according to the type of cell required.

The cell is then placed in a bath containing molten sodium or potassium nitrite, at a temperature of 330° C—350° C. The wire A is heated by means of an external current, and is maintained at a negative potential, relative to the fused salt. By electrolysis metal ions from the salt replace metal ions in the glass. The ions liberated in the glass are thus "pushed," as it were, on to the inner surface of the glass, where they become neutral metal atoms. This method has the advantage that the thickness of the layer can be regulated with the utmost precision, and the coating is so tenacious that silvering of the interior of the cell can be dispensed with.

In 1924 the Research Department of the General Electric Co. described an improved type of photo-electric cell. Fig. 6 gives the details of the construction. The cell is of the vacuum type, and though far less sensitive than the Elster and Geitel gasfilled type, they are absolutely

(*Continued on page* 363.)

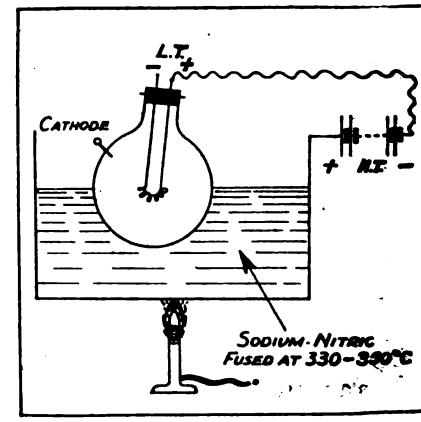

Fig. 7.—Experimental layout for making cells by electrolytic method.

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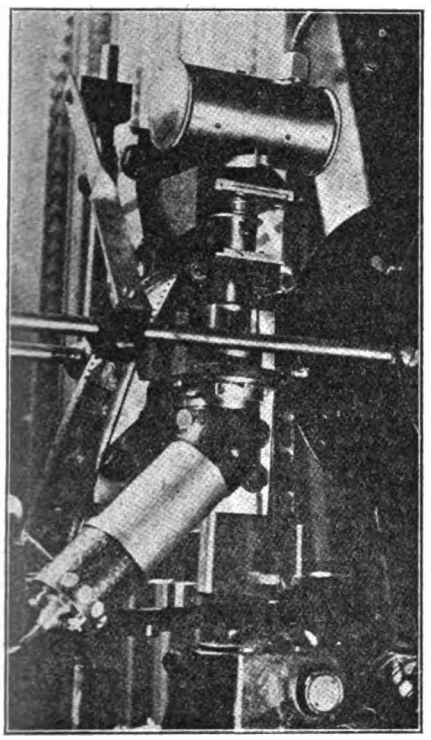

Photograph of a well-known type of "talkie" reproducer. The sound track is on the edge of the film. The photo-electric cell is housed in the metal cylinder at the top.

Tele-Cinematography

By NORMAN J. NICOLSON

In the general Press recently much attention has been directed to the work of foreign investigators in connection with the transmission, by what may be termed Television methods, of cinematograph films. The writer of this article very justly points out that in this country, Mr. J. L. Baird conducted experiments along these lines several years ago, but dropped them in order to devote his time to the main problem—Television. Our contributor explains Mr. Baird's recent work in tele-cinematography, and gives some details of the process.

DURING the time that Mr. Baird has been busily engaged with his endeavours to achieve true Television in this country, others abroad, less ambitious or less optimistic, have been working along more or less parallel lines, but have confined their efforts to attempting to reproduce films by televisual methods.

Jenkins, in America, and Mihaly on the Continent, have, in fact, concentrated on perfecting this in preference to actual Television, believing possibly that the accomplishment of Tele-cinematography would point the way to Television.

Baird's Early Experiments.

What is, perhaps, not generally known, is that Mr. Baird, several years ago, during his early experiments, acquired a small projecting apparatus, and proved to his own satisfaction that his methods, then just emerging in a concrete form, could successfully be applied to film reproduction. In his eagerness to reach his goal, however, he did not further pursue at that time what to him was merely a sideline to Television proper. Recent publicity accorded to Tele-cinematography, as though it were a new invention, has provided the occasion for Mr. Baird to re-instal his cinema plant for demonstration purposes, together with a sound reproducing outfit (the latter naturally being a new addition) with results that are in every way satisfactory, so that to him must be accorded the credit of evolving Tele-cinematography combined with Talkie reproduction, or, briefly, "Tele-Talkies."

Broadcasting Talking Films.

In this article it is proposed to explain, with the aid of diagrams, the main essentials in the televising of a film image, and the accompanying sound record, with a view to the broadcasting of talking films. It is well to point out from the start that there are no more peculiarities attached to the reception of Tele-Talkies by radio than there are to ordinary television. As emphasised in an earlier article, all the fare provided by television is capable of reproduction on the same "televisor," whether that fare includes film transmission, studio scenes, or daylight television. The complications arising are almost all at the transmitting end.

Citing Talking Films to illustrate this point, the projectionist at a theatre treats a film reproducing the surf breaking on a beach in exactly the same way as he treats one which records an artist's voice in a draped studio, apart from some essential variations in his volume control. The apparatus which records the different sounds on the film, however, has to be handled quite differently to suit each case. Technically, Tele-Talkies are much easier to broadcast than Television, because up to a point we are in the same happy position of the projectionist.

The lighting of the subjects, the backgrounds, scenery, positions of the artists, balancing of voices and effects, microphone positions, etc., have all been thought out and done for us in the film studio, in sharp contrast to televising a scene or stage, where everything has to be attended to at the televising point. In fact, when one pauses to consider the matter, it is obvious that a Television broadcasting Studio will call for a new technique and organisation of no mean order. In Tele-Talkies we can cut out all studio complications, and broadcast the films direct from the control room. The potentialities of this, of course, are enormous, and permit of giving free rein to one's imagination.

Apparatus Required.

The apparatus needed to televise the film picture will be described quite simply. We need a film projector, a condensing and projection lens, a rotating disc, perforated with the usual number of square holes arranged in a staggered spiral, a spot controlling gate, one photo-electric cell only, and an amplifier. Illustrated theoretically in Fig. 1 (*A*) we can see the optical system used to convert the picture into electrical impulses. This may be regarded as a reversal of the Spotlight System of scanning used in Television, although in principle it remains the same, insofar as the illuminated picture is exposed to the photo-electric cell, one spot at a time.

In the drawing, we see the source of Light *L*, concentrated by a condenser *CC* on to the film which is passing through the usual cinema projector gate *G*. The lens *LL* projects the image of the film on to the scanning disc *DD*. This image is

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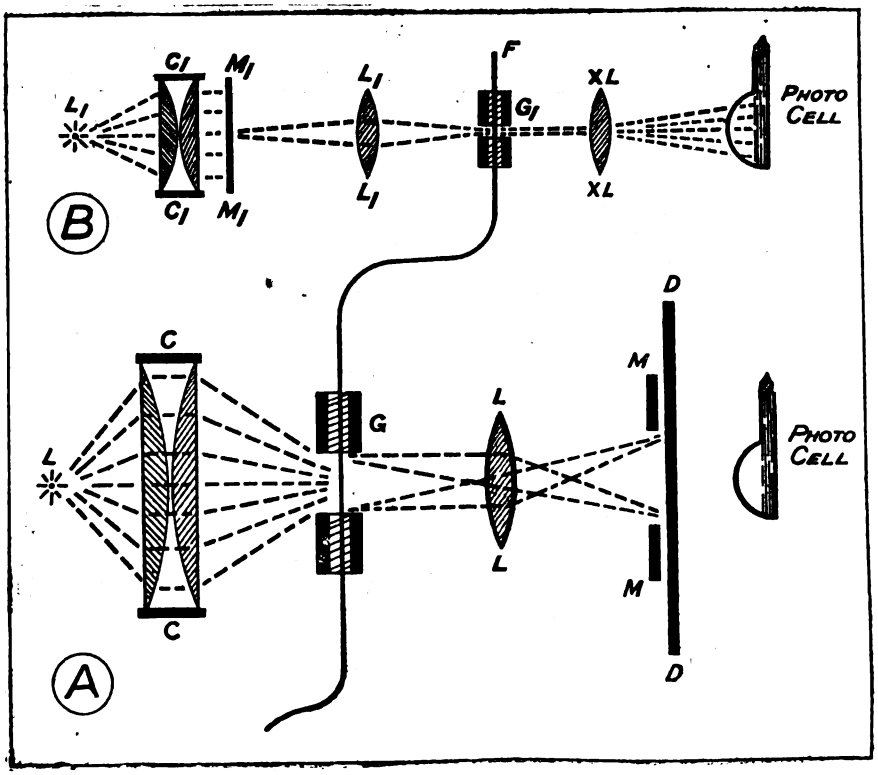

Fig. 1.

Theoretical diagram of apparatus for transmitting a talking film. No attempt has been made to show the mechanism for moving the film, or to draw the diagram to scale. (A) shows the picture transmission section and (B) the sound transmission section.

only slightly larger than the original film, to suit the scanning area, which in itself is quite small. The spot control gate *MM* ensures that only one aperture is exposing the picture to the cell at a time. Therefore, as the disc revolves, the apertures pass over the image, and allow its varying light values to fall on the cell strip by strip. The cell converts these values into corresponding electrical impulses. The resultant signals are amplified, and, as in Television, are available for transmission by wire or wireless.

Televising "Close-ups."

By skilful manipulation of the disc position and the lens *LL* we are in the position to scan either the entire film or to pick out any particular artist and to enlarge him or her up to a close-up effect as we wish, and follow the movements throughout.

If the reader refers to the previous article on the Spotlight principle of Television in the June issue of this magazine, he can see that with the exception of the film and general arrangement, the apparatus is similar. In Television the cell responds to *reflected* light values only, but in tele-cinematography a shadow image is explored by the disc, the cell being excited by *direct* light values.

In the theoretical diagram, no mechanical device is shown for moving the film. In cinema projection, this device is such that the film is moved before the light in rapid jerks, and whilst it is being moved from one picture to the next a synchronised shutter cuts off the light. This, of course, calls for a very accurate timing arrangement when we set out to scan a film picture, as obviously we would complicate results badly by scanning during the period of transition from one picture to the next. What has to be done is to time the shutter with the disc, so that one revolution of the disc coincides with the exposure of each picture, and the shutter operation takes place during the brief interval between the end of one spot traversal and the beginning of the next. An alternative is to use a projector of the type which has no shutters.

In Fig. 2 the perforated disc is seen with its mask or gate *MMMM* for controlling the spot. The opening in this is drawn so as to show the actual scanning strips, and its vertical length is such that there is a short yet decided period when no spot is traversing the image. The direction of scanning is the same as in Television *viz.*, the spot exposed by the apertures in the disc travels from the bottom right hand corner upwards, as represented diagramatically by *A* in Fig. 3, the spots following each other in the direction of *B*. Memorising the direction of the arrow *R* will therefore prove to be a great help in making and fitting up Television apparatus.

The Sound Reproducer.

With regard to the sound reproducing apparatus, one immediately realises that up to a point there is much in common between this and the visual reproduction. Instead of a spot, however, a narrow slit of light plays the important part. The optical layout is drawn theoretically in Fig. 1 (*B*) where we see the source of Light *Ll*, concentrated by the condenser *CC* on to the mask *MM*, in which a narrow slit is cut. The lens *LL* projects an image of this slit, greatly reduced in size and focussed on to the narrow edge of the film, depicting the sound record passing through the gate *Gl*.

The light, consequently, passes through the film proportionately to the overall density of the sound track on the film, and is evenly dispersed by the Lens *XLXL* over the cathode of the Photo-cell. This cell is connected up in the usual manner to an Audio frequency amplifier. It is customary to use four or more stages of amplification after the cell, in order to bring the signal up to the standard necessary to operate a moving coil loud speaker, but in Tele-Talkies, as we only need sufficient volume to modulate a wireless trans-

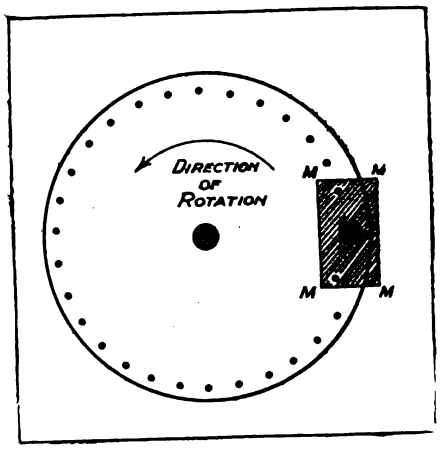

Fig. 2.

Illustrating how a film is scanned.

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mitter, three stages are found to be ample.

Synchronism.

As regards synchronism between the sound and picture, we are more or less at the mercy of the film studios in that respect, or at all events, at the mercy of their printing department. Owing to the necessity of providing an even feed through the talkie gate, as opposed to the jerky feed through the picture gate in a standard projector, an appreciable loop of film has to be allowed between the two, which means that the sounds relating to one particular picture have to be printed on a different portion of the film a certain distance along, either ahead or behind that picture, depending whether the talkie reproducer is fed before or after the picture, and the length of the loop necessary, before we can obtain synchronism in our results. Film producing interests are endeavouring to establish a standard in this respect, but at the moment in many cases it is necessary to print talking films specially for some projectors. Provided, therefore, that the interval between the picture and its accompanying sounds is accurate and in the right direction synchronism in the Tele-Talkies is bound to exist.

Television v. Tele-cinema

Those readers anxious to learn details of sound-recording work on films (and it is a fascinating study), are advised to peruse the report of the May meeting of the Television Society, published in the June issue of this magazine, and also the interesting description of the Society's visit to the British Talking Pictures Studios, in the August number.

Whether the televising of films will have any advantage over televising actual scenes has yet to be discovered. In regard to Television broadcasting, it is safe to predict that they will dovetail harmoniously in the making up of a programme. Tele-Talkies will be comparable to the gramophone recitals in our existing broadcast programmes.

Lighting Problems.

One point occurs to the writer, and that is the problem of artistically lighting the artist in the photographic sense of the word. This at the moment is an unexplored field in Spotlight Television, and may or may not prove to be easy of accomplishment. We know it can be done in Tele-cinematography, because the lighting is already there on the film. Film lovers have become accustomed to those lovely touches of light on the waves of the blonde star's hair, those strikingly Rembrandt effects in connection with close-ups, and will naturally look for similar effects in their Televisors.

It would be premature at this stage to state that in consequence of Mr. Baird's Tele-Talkie success any talking film could be broadcast, but it is safe to say that the foundation has now been laid towards the attainment of

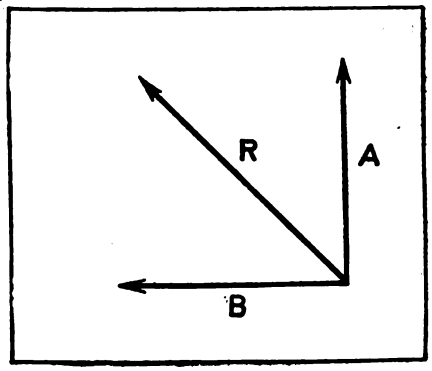

Fig. 3.
Illustrating the direction of the light spot in television and tele-cinematography.

that end. At present Tele-Talkies are subject to the same difficulties which beset Television, in so far that the wave band restriction does not permit of adequate reproduction by wireless of more than semi-close-up scenes, and individual artists, but these can be portrayed with equivalent faithfulness to the film screen itself. When the sideband obstacle is surmounted, in the ordinary course of development, talking films of any description may be broadcast and received in the home.

Television Society.

(*Concluded from page* 357.)

forward to a very full and interesting programme during the winter months. The Second Annual Exhibition of members' work will take place in March 1930, which it is hoped will be even more representative than that held this year. Our President, Sir Ambrose Fleming, hopes to be present on this occasion and all members will wish to make this gathering really representative of the work of the Society. We must individually do our share in showing, through the exhibits, that real progress is being made. Members are therefore asked to bear this exhibition in mind in the course of their experimental work and to get in touch with the secretaries as soon as possible if they can contribute apparatus, or if they have suggestions to put forward. Correspondence and constructive criticisms on this or other matters affecting the welfare of the Society, are always welcomed at headquarters. One or other of the secretaries can be seen, by appointment, by writing to the head office :—

4, Duke Street, Adelphi, W.C.2.

J. J. DENTON, A.M.I.E.E.
W. G. W. MITCHELL, B.Sc
Joint Hon. Secretaries.

The Practical Evolution of the Photo-electric Cell.

(*Concluded from page* 360.)

trustworthy, in that they exhibit no time lag or fatigue.* Moreover, cells of practically uniform characteristics can be prepared, so that no two cells differ in sensitiveness by any appreciable amount.

Since a detailed review of the newest G.E.C. type of cells appeared in the July issue of TELEVISION, the reader can conveniently be referred to the issue in question for particulars.

Finally, might I suggest that, to those sufficiently interested, the manufacture of cells of the Zworykin type for experimental use presents an interesting and not too difficult problem? A gasfilled motor headlamp bulb should have a platinum wire fused in to the glass envelope, at some convenient point. As much of the glass as it is desired to coat with the photo-sensitive surface should then be immersed in the bath of fused nitrite, and the filament lighted from a suitable accumulator. A high tension battery of 100—200 volts should then be connected as shown in Fig. 7, so that the metal container with the fused salt is connected to the positive, while the negative H.T. is joined to positive L.T. Some hours are necessary to get a suitable coating of alkali metal. In use the filament forms the anode of the cell.

* TELEVISION, No. 8, p. 32.

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Aberrations of Lenses and Optical Systems

Part XIV

By Professor CHESHIRE, C.B.E., A.R.C.S., F.I.P.

MEASURING sticks must, to secure accuracy and ease in use, be of the same order of magnitude as the quantities to be measured. The astronomer, for example, when plumbing celestial depths, measures them in light-years, a light-year being the distance traversed by light in one year, at the rate of 186,000 miles per second.

The tailor measures his cloth with a yard-stick; and the physicist, and optician, having to deal with and measure quantities of the order of a millionth of an inch, or less, uses the length of a light-wave as his measuring stick.

The use of the length of a light-wave for measuring purposes is made possible by a fundamental property of wave-motion—that of "*interference*," so-called.

Interference of Waves.

One of the most charming and instructive ways of studying wave-motion is to stand by the side of a calm and unruffled pond, which reflects an expanse of sky to the eye, and throw in a number of pebbles. A single pebble falling into the water produces the well-known sight of a number of ripples starting from the splash, and chasing one another in the form of concentric circles over the surface of the pond. A handful of pebbles thrown in produces a criss-cross ripple pattern of extraordinary complexity and beauty, which the mathematician has disentangled for us in a very simple way.

To understand this let us suppose that two pebbles fall into the pond at the same instant, and at a few feet apart. Each will produce its own system of ripples, so that a floating cork, or leaf, in the neighbourhood, will be acted upon by both sets of ripples. A laboratory modification of this experiment in shown by Figs. 1 and 2.

The former of these is a sketch of an instantaneous photograph of two interfering ripple systems* on the surface of a bowl of mercury. Fig. 2 shows the diagram explanatory of the interference pattern of Fig. 1.

The ripple producer employed for this experiment was a large tuning fork, one of the prongs of which was fitted with a piece of bent wire, the two ends of which dipped, at points an inch or two apart, into and out of the mercury simultaneously, as the prongs of the fork vibrated. In this way a constant stream of ripples of the same frequency as that of the fork was started and continuously propagated from each of the two points O^1 and O^2.

Further, as each ripple starting from one point was precisely similar to the ripple starting simultaneously from the other, they were in the same phase; crest starting with crest and trough with trough. The ripple system for each point, considered independently of the other, is, as shown, a series of equidistant concentric circles. The full lines, Fig. 2, represent crest, whilst the troughs, of course, occur between them. Let us consider the middle line M, M, which joins up points at which the ripple crests from one point O^1, arrive simultaneously with crests from the second point O^2.

Further it will be seen that the ripple troughs, too, arrive simultaneously at all points on this line from the two points O^1, and O^2. In fact, at any point along this line it is evident that the two sets of ripples which reach it always do so in the same phase.

What then results?

The answer is that in consequence of this superposition of wave motions in the same phase, all the particles along the line M, M, move up and

* Taken from a delightful book on "Light Waves and their Uses," by Professor Michelson, of Chicago University.

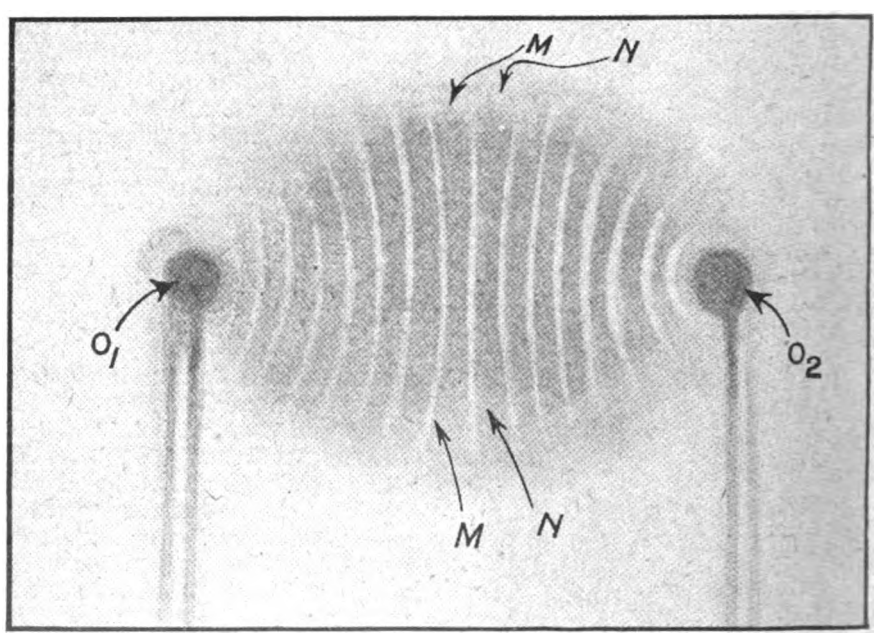

Fig. 1.
Interference of waves produced by two point sources.

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down through twice the distance that they would do under the influence of one set of ripples alone.

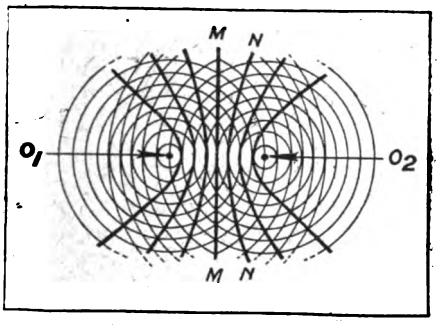


Fig. 2.
Diagram of the wave-pattern of Fig. 1.

M, M is, therefore, a line of maximum motion. The black line *N, N* immediately to the left of *M, M* is also a line of maximum motion, but the ripples from O^1, reach it two wave-lengths ahead of those from O^2.*

Between any pair of adjacent lines of maximum motion, drawn for a retardation of a single wave, there must clearly be a line of points at which the two sets of ripples arrive in opposite phase, *i.e.*, a line at all points of which crests are superposed on troughs—a line of minimum motion.

Lines of Rest and Motion.

These alternating lines of maximum rest and motion have been beautifully photographed by Professor Michelson as shown by Fig. 1.

This figure shows how, in the case of two sets of ripples acting together, motion may be superposed on motion to produce rest. Musical beats afford a similar example in sound.

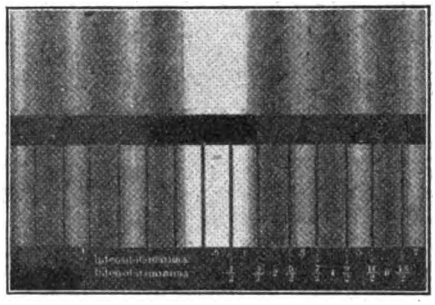
If two similar tuning forks are vibrating simultaneously it happens, for certain positions of the ear, that a compression from one of the forks reaches it at the same instant as a rarefaction from the second fork. Under the action of the compression the drum of the ear would be driven in; under the action of the rarefaction it would be driven out. Under the action of both it remains at rest and silence results.

Similarly, as we shall now see, it is possible to superpose light on light and produce darkness, an experimental fact which in the hands of Young and Fresnel, at the beginning of last century, did so much to establish finally Huygen's wave-theory of light.

Interference of Light Waves.

There are many experiments which show in a simple way the principle of interference with light-waves. The oldest and best known of these is probably the soap bubble. A soap film is very thin, and should its thickness at any point be such that light reflected by one of its surfaces is superposed in opposite phase on the light reflected by the other surface, then darkness results when monochromatic light—a soda flame, for example—is used, and colour in the case of sun-light. An interference experiment closely analogous to that already described for mercury ripples can be carried out as follows:—

Experiment.—Expose to diffused light a photographic plate and cut it into halves. Take a penknife, or, better still, a knitting-needle ground to a chisel point, and rule a straight line across one of these plates, removing the emulsion in doing so. On the second plate rule a similar single line or slit, and, in addition, at some distance away, a pair of such lines parallel to one another and about a fiftieth of an inch apart. Each of the four slits thus made should have approximately the same width, but if this is made too narrow, sufficient light will not be passed by them. Our apparatus is complete.



Figs. 3 and 4.
Interference pattern produced by one (upper figure) and two slits (lower figure).

The single slit should be held vertically in front of a good light—a bright sky will do quite well—and at a distance of from six to eight inches from the eye. Now place the single slit of the second plate vertically in front of, and as close as possible, to the eye. A broad white central band will be seen (Fig. 3) flanked on each side by a succession of coloured bands which diminish in intensity as the distance from the central band increases.

Interference Patterns.

If now the slit in the first plate is looked at through the double-slit ruled on the second plate it will present the appearance shown by Fig. 4. The bands seen with one slit are crossed throughout by a number of vertical dark lines, and it will be found that lessening the separation of the components of the double-slit increases the separation of the dark lines seen, and *vice-versa*. Against the sun brilliantly coloured flanking bands will be seen, but against the sky very little more than the broad white central band with its fine dark vertical lines will be seen.

The way in which the lines or fringes are produced is shown by Fig. 5, which represents an eye in plan, looking through a double-slit at a single one.

Let light from the object slit *O* fall upon the two slits S^1 and S^2, placed in front of the eye. Light

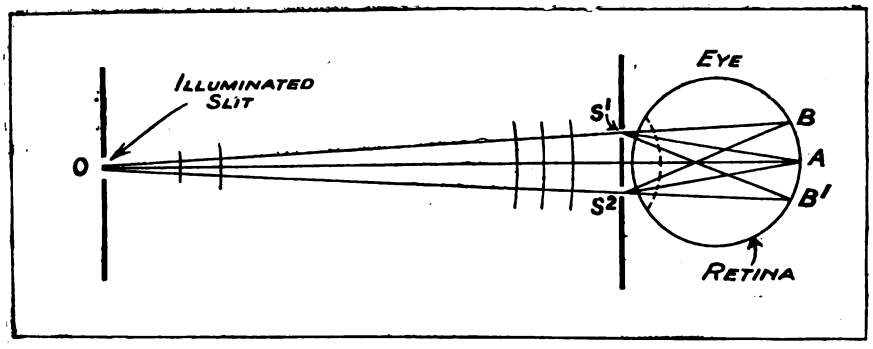


Fig. 5.
Action of double-slit in producing interference effects.

* Strictly speaking, the dark lines should be twice as great in number as those shown. The retardation in passing from one to the other should have been a wave-length only.

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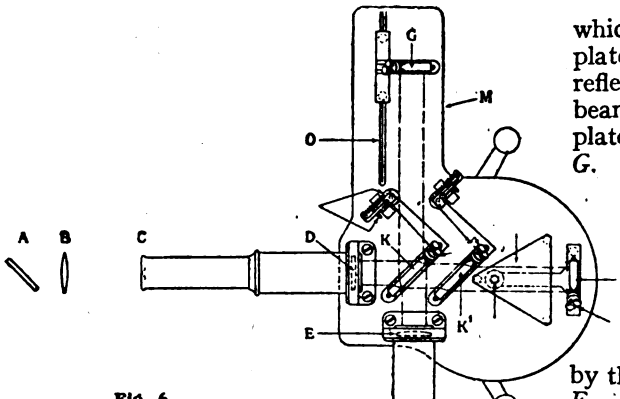

Fig. 6.
Interferometer.

waves will radiate from these two slits and fall upon the retina.* At the point A, equidistant from S^1 and S^2, these waves will be superposed in the same phase, producing the bright central band seen. At the point B, half a wave-length further away from S^2 than from S^1, the waves will be superposed in opposite phase and darkness will result.

Similarly at B^1. The distance B, B^1 is thus the distance between the dark bands or fringes, and a little consideration will show that this depends upon the distance between S^1 and S^2, the greater the latter the smaller the former.

Hilger's Interferometer.

Fig. 6 shows in plan a Hilger's interferometer, an instrument which is steadily coming into use for the refined testing of optical elements and apparatus such as prisms, photo and astronomical lenses, telescopes, etc.

Two plane-parallel plates K and K^1, the former of which is half-silvered on one surface, together with two first-surface plane reflectors F and G, stand and are adjusted perpendicularly upon a flat table-top of cast iron. Light, preferably that of a mercury vapour lamp, is directed by a mirror A to a lens B, which brings the light to a focus in a small aperture C, which is also at the focus of a collimating lens D. The parallel beam from D falling upon the plate K, at an angle of about 45°, is divided into two beams, one of which is transmitted by the plates K and K^1 to the reflector F, whilst the second beam is reflected by the plate K to the reflector G. The reflectors F and G return the beams incident upon them along their own paths. That from F is reflected by K to the lens E, whilst that from G is transmitted by the plate K to the lens E. Finally both beams are brought to a focus by the lens E in the pupil of the observer's eye at P.

Light, therefore, passes by two paths from the aperture C to its image at P. One of these is by the lens D, plate K, plate K^1, reflector F, plate K^1, and reflector K to the lens E and aperture P. The second path is by the lens D, plate K, acting as a reflector, reflector G, plate K, acting as a transmitter, to the lens E and aperture P. The plate K^1, when used, acts to equalise the optical lengths of the two paths.

The interferometer may be used for a number of purposes. If, for example, it is required to find the wave-length of a particular monochromatic radiation, that light is focussed upon the aperture C, and the apparatus is adjusted until the usual fringes are seen in the field of view. The mirror G is then slowly moved backwards or forwards through an accurately measured distance l, say, along the slide O, and the fringes which pass across the field of view during this displacement counted. Then if n is the number of fringes counted, the wave-length λ is equal to $2l/n$. In a simila way it has been found that there ar 1,553,164·1 wave-lengths of the re cadmium radiation in the length c the standard metre.

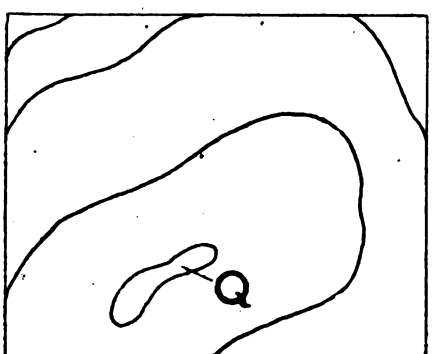

Fig. 7.
Fringe pattern on face of imperfect prism.

In the testing of optical elements such as prisms, designed to receiv plane waves and pass them on a such, the departure from planenes of the emergent waves is, in effect measured. The prism, say, is placed between the plate K and the mirror F and the latter is then adjusted t reflect the beam passing through the prism back again along its own path A fringe pattern such, for instance as that shown by Fig. 7 may be seen if the prism is imperfect. This fringe pattern may be looked upon as a contour map of the emergent wave-surface projected upon one of the faces of the prism.

In the case of lenses the plane mirror F is replaced by an accurately ground convex mirror which receives the convergent waves from the lens being tested, and returns them, more or less, as the aberrations present allow, along their own path.

* When light waves from a distant object fall upon a narrow slit, the slit itself becomes the centre of a new system of waves spreading out behind the slit in all directions.

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TESTING ELECTRICAL APPARATUS
THE "DROP TEST"

By CYRIL SYLVESTER, A.M.I.E.E., A.M.I.Mech.E.

IN any branch of electrical science in which various apparatus is used to produce certain results or effects, it is necessary to see with "the mind's eye" exactly what is occurring at any instant of time. To know that a certain result is being obtained is not sufficient; the progress from the *cause* to the *effect* should be thoroughly understood, since it is only in this way that any deviation from an anticipated result can be correctly interpreted.

Sound Knowledge Essential.

To the experimenter in Television a sound knowledge of the "happenings" from transmission to reception is most essential. Then, if the results obtained are not as anticipated, the cause of this deviation can be determined very readily. Apparatus for television transmission and reception includes many electrical components; any effect which varies from those normally obtained may affect, very considerably, the result of an experiment. It is simple indeed to realise that a piece of electrical apparatus is, not acting normally; it is not so simple, however, to determine the cause of the variation. A short-circuit or an open circuit in a coil, a defect in the armature of a motor, or even a dirty commutator produces results which are other than normal. These are faults which must be quickly and accurately located before further experimental success can be assured.

Little-known Tests.

The testing of electrical apparatus other than for "earth" or "continuity" is very little known. The reason is that, as a rule, all faulty apparatus is given to an individual who is known as the "official tester." This fellow is very secretive about his methods of procedure in fault location. It is obvious, however, that the experimenter in Television cannot afford to submit apparatus to a tester either from an expense or time wasted point of view. After all, the tests are very simple, it being merely a question of correctly interpreting the results obtained.

The most important test to be applied is known as the "drop test." This test does not take into consideration the electro-magnetic characteristics of any piece of apparatus; it is based simply on the drop of volts in a conductor. In Fig. 1, for instance, *A–B* is a conductor which, although continuous, may be said to be divided into sections 1, 2, 3, and 4. If a pressure or voltage is applied to *A–B*

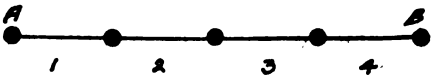

Fig. 1.

a certain amount of current will flow through the conductor. That is—

$$I = \frac{E}{R} \text{ or } E = I \times R \ldots (1)$$

where E is the applied pressure, the current in the conductor and R is the resistance of the conductor *from A to B*.

Simple Calculations.

Assuming E to be 10 volts it will be seen that the whole of this pressure is "dropped" in the conductor. If sections 1, 2, 3, and 4 have the same ohmic value the drop of volts across each section will be the same—i.e., 2·5 volts. If, however, the resistance of one section is higher than another the voltage drop will be different, although the current through *A–B* may be the same. If the resistance of each section is 2·5 ohms the current I will be—

$$I = \frac{E}{R} = \frac{10}{2 \cdot 5 \times 4} = \frac{10}{10} = 1 \text{ ampere.}$$

The drop of volts through each section is $1 \times 2 \cdot 5 = 2 \cdot 5$ volts. Let us now assume that the resistances of the sections are 4, 2, 3, and 1 ohms respectively. The total resistance is the same, so that, if the applied pressure remains the same, the current through the sections will be as before; the drop of volts across each section, however, will be different. Since $E = I \times R$ the various voltage drops will be 4 volts, 2 volts, 3 volts, and 1 volt respectively, thus making up the total of the applied pressure. We can now apply this reasoning to a piece of electrical apparatus. We will assume that the apparatus consists of three coils as illustrated in Fig. 2.

Effects of Short Circuits.

The function of a coil is to produce a magnetic flux; this is effected by a certain amount of current passing through a certain number of turns, the combination being known as ampere-turns. The coils are carefully designed so that any variation of current or turns will alter the magnetic effect. In high resistance coils the short-circuiting of a number of turns in a coil will not appreciably affect the performance of other coils which may be connected in series with it, yet the effect on the short-circuited coil may be considerable. The reason is that the amount of current is not reduced in proportion to the number of turns which are short-circuited.

Considering Fig. 2, let us assume that the resistance of each coil is 100 ohms and that the applied pressure is 300 volts. From (1) it will be seen that the current will be 1 ampere. If 25 per cent. of the turns in one coil are short-circuited the resistance of that coil will be reduced to 75 ohms;

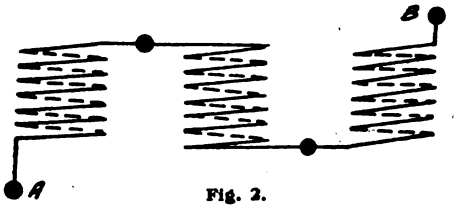

Fig. 2.

this, with the other coils, makes a total resistance of 275 ohms. The decreased resistance results in increased current, the new current value being 1·1 ampere; this is an increase of 10 per cent. The net effect on the short-circuited coil is 25 per cent. decrease through short-circuited turns and a 10 per cent. increase due to additional current through the other turns.

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The voltage drop, as determined by a voltmeter, across each coil will be from (1) 110 volts across the healthy

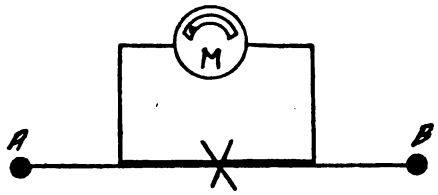

Fig. 3.

coils and 80 volts (approx.) across the faulty coil. This makes a total of 300 volts, the pressure lost in the three coils. From this it will be seen that the effect of a short-circuit in a coil is to decrease the voltage drop across the faulty coil and to slightly increase the voltage drop across the healthy coils.

Voltmeter as Tester.

The case I have quoted is a simple one, and an ordinary voltmeter may be used for determining the voltage drop. Some circuits are more complex than series circuits; some are connected in parallel and series parallel, when greater care has to be taken in interpreting a result. Here the instrument to be used is a milli-voltmeter; it is very sensitive and will respond to very small variations of current.

In Fig. 3 is illustrated a conductor *A–B* across a portion of which is a milli-voltmeter, *M*. The instrument may be said to be " shunted " across the conductor. The resistance of the conductor is constant so that any variation in the deflection of the instrument needle across its scale is due to increases or decreases in current through the conductor. If the conductor is broken at *X* (a condition which is equivalent to an open circuit) the instrument may be said to be across the supply, so that a maximum deflection will be obtained on the scale. The resistance of the conductor is very small, so that even slight variations in resistance will result in large needle deflections. We can now apply this reasoning to the testing of, say, the armature of a fractional horse-power motor.

Testing a Motor Armature.

The armature coils which are connected in series have their ends brought out to adjacent commutator segments so that complete continuity exists round the whole of the winding. If, therefore, current is passed through them as indicated in Fig. 4, we have current passing through a divided circuit of two circuits in parallel, each of which consists of a number of coils in series; this is shown in a schematic manner in Fig. 5. The dots between each coil represent the commutator segments. For simplicity only six coils are shown, these being connected to six segments.

From the illustration it is clear that if current is passed through the armature from *A* to *B* there will be an equal amount of current through each circuit. Also, since the resistance of each coil is the same the voltage across adjacent commutator segments will be the same. If a slight short-circuit exists in any one coil the amount of current may not vary sufficiently to be detected by an ordinary ammeter which measures current values, but it will be detected by the milli-voltmeter.

Short-circuit Indications.

If the instrument is placed across adjacent commutator segments in turn the same deflection at each point indicates that the whole of the coils are healthy. If a smaller deflection is obtained across any one coil then it points to the fact that the voltage across that coil is less than that across the others. Since the current is practically constant the only conclusion to be drawn from the deflection is that the resistance value has altered; that is, that it is less than it was when the coil was healthy; this points to the fact that some of the turns must be short-circuited.

Considering Fig. 5 further, an open or broken coil in either circuit would be manifest from the fact that normal

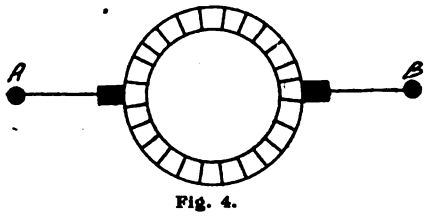

Fig. 4.

deflection would be obtained across three coils whereas, across the other three coils, the instrument needle would pass right over the scale. In this way it will be seen that the state of an armature winding can readily be determined from a short-circuited coil to even short-circuits between coils.

Using a Galvanometer.

A sensitive galvanometer will act as a milli-voltmeter; it should be permanently shunted across a conductor and the current adjusted to produce a reasonable deflection. The reason for shunting the instrument is to protect it against excessive current which would flow through it when an open circuit is encountered. A little experimenting with resistances of

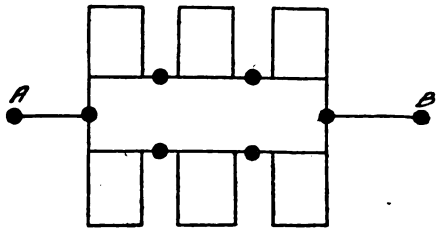

Fig. 5.

known value, or coils whose resistances are known, will soon make one quite expert in detecting and locating faults.

Novel Outside Broadcast Arrangement.

When the German airship, the Graf Zeppelin, arrived at Lakehurst, New Jersey, special arrangements were made to broadcast a description of the arrival scenes over the nation-wide network of the National Broadcasting Company of America.

Profiting by the experiences gained on the occasion of the Graf Zeppelin's first visit to America the O.B. engineers of the National Broadcasting Company abandoned all efforts to place microphones at various vantage-points around the landing field. Instead they equipped the announcer with a portable short-wave wireless transmitter. This transmitter weighs only 24 lb., and was originally developed by the N.B.C. engineers for the use of a parachute jumper who broadcast his sensations while falling through the air.

By means of a short-wave receiver installed inside the hangar, the announcer's description was picked up and relayed to broadcasting stations situated all over the United States. Such arrangements gave the announcer complete freedom of movement and enabled him to move about the field at will to points of interest.

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VOL. 2 OCT. 1929 No. 20

B. B. C.

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THE WORLDS FIRST TELEVISION JOURNAL

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THE TELEVISION SOCIETY

The Television Society was founded on September 7th, 1927.

The Society makes its appeal to those who desire to share in the responsibility of furthering this new branch of applied science.

THE OBJECTS OF THE SOCIETY

may be summarised as follows :

(*a*) The Study of Television and its application in applied science and industry.

(*b*) To afford a common meeting ground for professional and other workers interested in current research relating to Television and allied subjects and to afford facilities for the publication of reports and matters of interest to Members.

(*c*) To encourage the formation of *Local Centres* of the Society in the Provinces, so that by social intercourse and discussion among members these aims may be more fully realised.

The present register indicates a world-wide membership.

ORGANISATION.

The Society consists of one Honorary Fellow, Fellows and Associates, and the management is vested in a Council of Fellows, including the President, three Vice-Presidents, and Ordinary Fellows.

FELLOWS.—Ordinary Fellows must be elected by the Council. Candidates for the Fellowship must be proposed by two Ordinary Fellows, the first proposer certifying his personal knowledge of the candidate.

ASSOCIATES.—Any person over 21 interested in Television may be eligible for the Associateship without technical qualifications, but must give some evidence of interest in the subject as shall satisfy the Committee.

STUDENT MEMBERS.—The Council have arranged for the entrance of persons under the age of 21 as Student Members.

SUBSCRIPTIONS.—The annual subscription for Ordinary Fellows is 20s., with an entrance fee of 10s. 6d. ; and for Associates 10s., with an entrance fee of 5s.
The annual subscription for Student Members is 5s., entrance fee 2s. 6d.

LIFE MEMBERS.—Life Membership may be secured at a fee of £10 10s.

MEETINGS.—The ordinary meetings of the Society are held in London at the Engineers' Club, Coventry Street, W.1, at 8 p.m., on the first Tuesday of the month (October to May inclusive). Notices of meetings are posted to all members about seven days before the meeting.

Full-size reproduction of the new Television Society Badge, which is available to accredited Members, and may be obtained from the Head Office, price 1s.

The official organ of the Society is " Television," published monthly by the Television Press, Ltd., 26, Charing Cross Road, W.C.2.

A memorandum for the guidance of members wishing to form a Local Centre of the Society may be obtained (gratis) on application to the Joint Hon. Secretaries, 4, Duke Street, Adelphi, W.C. 2.

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Television

THE WORLD'S FIRST TELEVISION JOURNAL

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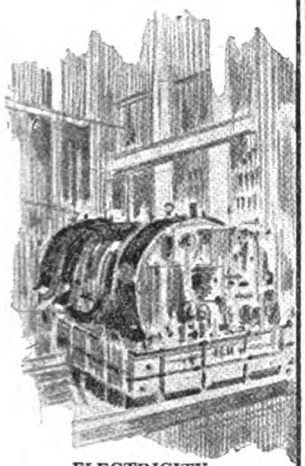

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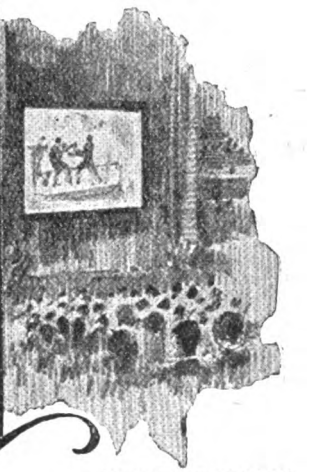

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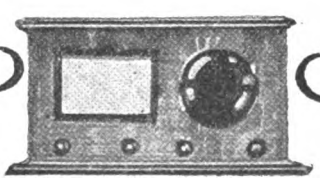

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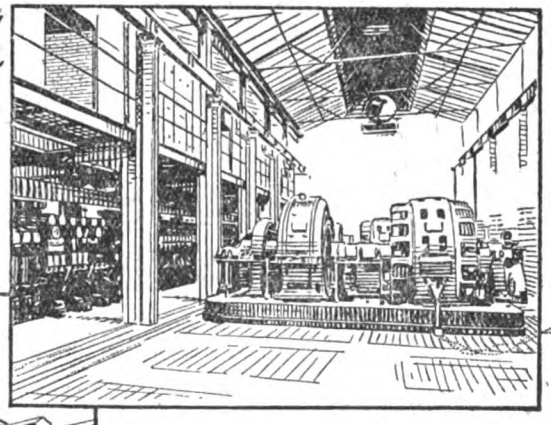

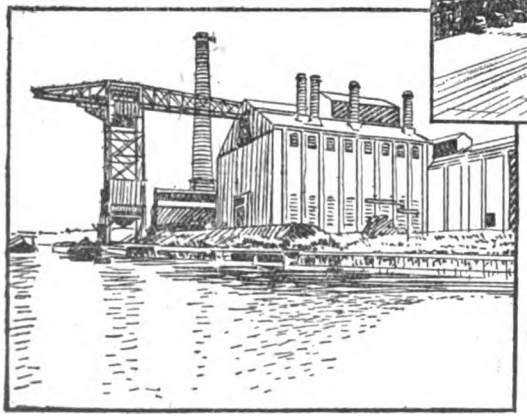

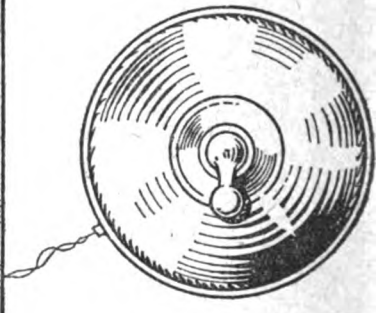

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THE WORLD'S FIRST TELEVISION JOURNAL

The Official Organ of The Television Society

Edited by A. DINSDALE, A.M.I.R.E.

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Technical Editor: J. C. RENNIE, B.Sc., A.M.I.E.E.

Vol. II] OCTOBER 1929 [No. 20

EDITORIAL

NO doubt our readers have already read in the newspapers the joint statement of the B.B.C. and the Baird Company to the effect that the B.B.C. will commence to broadcast television on September 30th. A start is being made at last, after months of protracted and frequently interrupted negotiations. We make no apology for drawing attention to the very active part which we have taken in the struggle to secure this result. We look back upon our share in the fight for broadcasting facilities, and survey the result with justifiable pride.

* * *

TELEVISION has come to stay. It has had many setbacks in the past, and may have many more in the future, but despite all troubles and difficulties, there is no question or doubt that television has come to stay. Our reason for being so definite on this point is because *this latest product of scientific endeavour provides something which the public wants.* It supplies something which broadcasting has always lacked, SIGHT.

* * *

IT was because we realised this very early in the life of this magazine that, at the risk of being accused of bias, we formulated the policy which we have been pursuing. In its fight for recognition and proper facilities we have consistently and actively supported the only organisation (the Baird Company) which can supply British broadcast listeners with this priceless thing, sight. We intend to continue that policy, for we are even now only at the beginning.

* * *

THE latest offer of broadcasting facilities which the Postmaster-General made to the Baird Company, and which the latter accepted, is by no means all that one would wish. It is perhaps natural that both the Postmaster-General and the B.B.C. should

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disclaim all responsibility for the success or otherwise of the experiments. Nevertheless, both parties can, and we feel sure they will, do much to make success certain. However perfect the transmissions may be (within the present limits of the art) when they leave the Baird studios, much depends upon the technical excellence of the Post Office land lines to 2LO and on the adjustment of the 2LO transmitter. The unvarying technical excellence of both these factors, as demonstrated daily in ordinary broadcasting, is of such a high order, however, that we feel sure there is no cause for anxiety on those scores.

* * *

THE facilities which have been offered and accepted cannot under any circumstances be described as ideal. The experimental transmissions are to last half an hour only, and that half-hour is between 11 and 11.30 a.m., a time of day when most of us are at business. On Saturdays and Sundays, the very days when most of us do our experimenting, there are to be no transmissions. Surely something could be done to rectify this anomaly, which amounts almost to an injustice to the experimenter.

* * *

THEN there is the question of security of tenure. Nothing is so upsetting as uncertainty. Neither the Postmaster-General nor the B.B.C. guarantee that the transmissions will be continued for any definite period. Apart from the effect of this upon the domestic arrangements of the Baird Company, there is, as we have already pointed out in these pages, the effect upon the manufacturer and also upon the experimenter. Uncertainty as to the future does not encourage either the manufacturer or the customer to expend money on apparatus which may be rendered useless overnight by a decision to discontinue broadcasting television. Fortunately, however, there is a safeguard in this direction, which we will deal with presently.

* * *

BEFORE closing this subject, we cannot do better, in order to indicate the feelings of our contemporaries, than quote from *Nature* of September 21st, which expresses itself as follows: "We hope that these experiments will be successful and that television will soon take a permanent place in our everyday life. In particular, we shall be interested to know the breadth of the band of frequencies required in the ether; the trend of invention seems to be in the direction of narrowing this band very appreciably."

* * *

Constructional Articles.

NOW that television broadcasting is about to start, the Baird Company has abandoned its policy of secrecy (made necessary in the past by commercial considerations) and released full details of the Baird televisor receiver. We are therefore hastening with all speed our preparations to give our readers the constructional articles for which they have waited so long and with such commendable patience. We hope to be in a position to publish the first of these in our November issue. There is sure to be a rush for that issue, so place an order with your newsagent NOW.

* * *

News from Abroad.

FROM press cuttings and direct information received from South Africa it is clear that the television demonstrations which Lord Angus Kennedy has been giving there recently have met with the greatest success and aroused the utmost enthusiasm. Scepticism has been completely killed, and the broadcasting authorities realise that television is here, and that what remains to be done is merely a matter of negotiation and detail. In our next issue we hope to be able to chronicle further interesting news from South Africa.

* * *

A FULL report of the state of television in Germany is published elsewhere in this issue. As far as other European countries are concerned, we understand that the only reason why Baird television is not already being broadcast from several powerful stations, easily receivable in this country, is that the Baird Company, however fast they recruit men, cannot provide sufficient trained engineers to meet all the demands from abroad.

* * *

Olympia.

AS mentioned above, the television section of the Berlin Radio Exhibition is fully described in this issue. And now, the British Radio Exhibition at Olympia, which will be open this year from September 23rd to October 3rd. Readers will find us in the gallery, at Stand 241. This is immediately on your left at the top of the staircase which you will find facing you as you enter the Exhibition. You are cordially invited to call and see us at our stand.

* * *

BY special arrangement with the Baird Television Development Company demonstrations of the Baird system of television will be given under our auspices, during the period of the Exhibition, at No. 1, Hammersmith Road (entrance in Addison Bridge Place). This is opposite Olympia. Although we have secured commodious premises there is, of course, a physical limit to the number of people who can be accommodated at any given time, and we have so organised the demonstrations that every member of each party will be assured of a good view not only of the receivers but also of the transmitting studio and control room. These two features have been specially arranged for this purpose. Everything will be clearly visible.

* * *

ADMISSION to the demonstrations will be by ticket only. These tickets will be given free, but must be applied for at our stand in the Exhibition. They cannot be obtained anywhere else.

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Television and Photo-telegraphy

By J. ROBINSON, M.B.E., D.Sc., Ph.D., M.I.E.E., F.Inst.P.

One of the obstacles to the perfection of broadcast television, as our readers know, is the present congestion in the broadcast waveband. Dr. Robinson points out that, throughout the field of wireless communication, those interests which were first in the field are maintaining a monopoly grip on all the available wavebands. He suggests that, throughout the world, those interested in the latest forms of communication, television, photo-telegraphy, and facsimile transmission, should band together for the one purpose of breaking this monopoly grip and forcing the older interests to yield space for the new arrivals.

ABOUT one year ago the general public throughout the world was made aware that startling developments were being made in wireless, and that new means for converting wireless waves into intelligence were being introduced. In place of the well-known telephones, loudspeakers or Morse inkers, it was being energetically put forward that wireless waves could be made to appeal instantly to the eye, and, in fact, that it was possible to transmit pictures.

On the one hand there was photo-telegraphy, by means of which a picture could be transmitted and received as a permanent record; and on the other hand moving pictures could be transmitted and received so as to be seen instantly as they arrived. There was then considerable confusion in the public mind as to the difference between these two different methods, and this confusion has even now not been completely dissipated.

Differences Between the Methods.

Technical people had no misconception as to the differences between the methods, and they proceeded to give a lead to the general public as to the kind of reception to accord to the two new applications of wireless. There were differences in the results, in the methods, and in the relationship to the general technique of wireless. Also there was a very large psychological difference in so far as one system recorded a picture whilst the other gave actual vision of life.

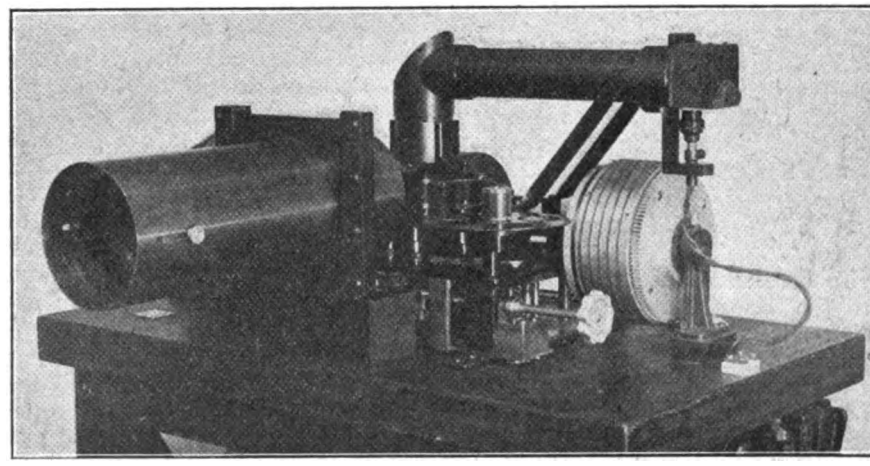
In view of the progress that has been made with both methods of optical recording of wireless communication, it may be of interest to discuss these differences at some length. In doing so it will become obvious that there are some very large features of similarity, which demand closer co-operation between the workers in the two fields, in all parts of the world.

Although it was only during last summer that the public became aware of the possibility of optical broadcasting and similar applications, much work had been done by inventors and engineers for many years previous to this. Such good progress had been made in some countries that it became essential to widen their activities, and to obtain financial assistance, which was forthcoming by the formation of public companies.

It is a very curious fact that although undoubted progress had been made both with the transmission and reception of telegraphed photographs and television, some engineers resented the steps taken to acquire financial assistance from the public; and in at least one case the statement was made that such developments should be taken completely out of the hands of the inventors, who had already done so much, and given to research organisations which already exist, such as the research laboratories of the large electrical companies. Fortunately, however, the modern world is prepared to admit that the large recognised research associations have not a monopoly of brains, and they do come to the assistance of promising inventors who are working independently. From a technical point of view the progress made during the last twelve months has justified the confidence of the public.

Mechanical Scanning.

Before proceeding further, one might be excused for referring to one other criticism of last year, that television could not hope to progress with the mechanical methods of scanning. It is a significant fact that in all practical systems of photo-telegraphy and television trans-



Close-up view of Telefunken-Karolus tele-cinema transmitter, showing optical arrangements used in connection with the scanning mechanism.

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mission there is to-day only one general system of scanning the picture, and that is the mechanical method. Again, the good sense of the public has prevented criticism from delaying legitimate progress.

If we wish to transmit a picture from one place to another by wireless or by wire, we divide the picture into a number of parts and convey a signal for each part. When received, the various signals, which are of an electrical nature, are converted to optical effects, and correct arrangement of these made so as to give a correct picture.

There are thus certain essential processes for all systems of picture transmission whether still or moving: firstly, the division of the picture to be transmitted into a number of parts; secondly, the conversion of the light effect of each part into an equivalent electrical effect; thirdly, the transmission and reception of the electrical effects; fourthly, the reconversion of the electrical into optical effects; and fifthly, the correct arrangement of the optical effects into a picture. These processes are fundamental to both types of picture transmission.

The general result desired is to transmit pictures as perfectly as possible, and also, if possible, almost instantaneously. These two desirable features introduce the most important factor in optical broadcasting, i.e., *time*. Ignoring this factor, there is no fundamental difference in the principles of photo-telegraphy and television. However, when we do consider the time factor in conjunction with the perfection of the result which is desired, we find divergences in the methods applied to achieve the two distinct results.

Let us bear in mind always that there is only one ultimate object of all systems of optical broadcasting, and that is to obtain as good a picture or series of pictures in as short a time as possible.

The "Dot" Theory.

To consider the influence of time on the communication of optical effects, it is necessary to use some system of reference for the scanning of a picture. The simplest method is to consider the number of parts into which a picture is divided. When this subdivision is very extended, it has become customary to refer to the number of "dots" of a picture. This is by no means an ideal means for considering scanning, as it implies that each part of a picture or dot is separate from every other part, whereas, in fact, the picture is scanned quite continuously, so that there is usually no "dot" effect. However, for certain purposes the "dot" conception is convenient and we shall for the moment consider a picture of rectangular shape divided into 100 strips each way, thus having 10,000 rectangular parts or "dots." This is a crude subdivision, and in order to give the most faithful detail a picture should be divided into a much larger number of "dots."

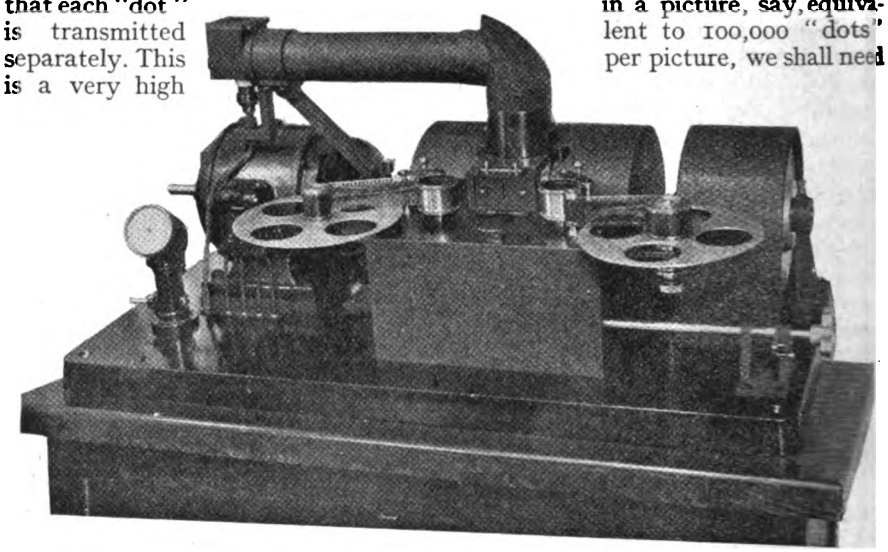
High Signalling Speeds.

Suppose that we wish to transmit the picture in this form in one second. We must transmit at the rate of 10,000 signals per second, assuming that each "dot" is transmitted separately. This is a very high signalling speed, for the assumption we have just made takes us into the telegraphic rather than into the telephonic field. In telegraphy any system capable of dealing with 10,000 independent signals per second would have an immediate commercial outlet, for this is equivalent to a speed of about 10,000 words per minute, and there is no system of telegraphy to-day which comes anywhere near such high speeds.

However, if we give up our assumption of the transmission of each "dot" separately, and use the practical method of scanning, we should have 100 strips to scan in one second, the width of the scanning aperture to correspond being equal to the width of the strip. In this case we approach the telephonic method of recording rather than the telegraphic, when the transmission of our picture becomes equivalent to the transmission of frequencies approaching 10,000 per second, the actual maximum frequency depending on how regular or irregular is the light distribution along one strip.

Returning to the "dot" conception again, a single picture of 10,000 "dots" could not be transmitted by telegraphic methods in one second, and to correspond to present-day practice of these methods, about 50 seconds would be required.

On the practical method of continuous scanning along a strip, it would be possible to transmit the picture of 10,000 "dots" in one second, as this would not involve frequencies higher than 10,000 per second. Now consider that we need a finer grain in a picture, say, equivalent to 100,000 "dots" per picture, we shall need to transmit frequencies approaching 100,000 if such a picture must be completed in one second, and as this is not allowed, we must take at least 10 seconds to transmit such a picture.



Another close-up view of the Karolus tele-cinema transmitter, with the optical parts removed.

Thus, in order to transmit a photograph telegraphically the time factor comes in, and the greater the detail of the picture the longer is the time required.

In the case of television the problem is different, for it is essential to transmit one complete picture in a fraction of a second, say, from one-tenth to one-sixteenth of a second. The problem is different because in the case of photo-telegraphy an actual optical record is made either photo-

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graphically or photo-chemically, whereas with television a fleeting image of each picture is all that is required, each complete picture being made in a fraction of a second, the pictures succeeding each other as in the case of the cinematograph, to give the appearance of continuous motion.

Suppose that we choose 10 pictures per second, we find that the definition of the picture must be restricted to about 1,000 "dots" per picture. This is equivalent to 10,000 signals per second, or on the continuous scanning system to frequencies approaching 10,000 cycles per second.

Different Objectives.

This is where the two different methods of optical transmission by wireless choose different paths. In photo-telegraphy we attempt to have the greatest possible detail and take a comparatively long time to transmit one picture; whereas with television the time factor is fixed, as each picture must be completed in one-tenth of a second, so that the definition of the picture is sacrificed. Further progress by both methods will be towards the same end, transmitting as large a picture as possible in one-tenth or one-sixteenth of a second.

At the moment organisations all over the world are working at these problems, and were there no fundamental difficulties it is certain that the final solution would be obtained by people working along these different lines.

There is, however, a very important difficulty in the way of both methods, which is that the rate of transmitting the "dots" either continuously or separately has an unfortunate effect on wireless waves. To transmit 10,000 "dots" per second means that frequencies approaching 10,000 cycles per second are involved, and if the highest frequency is 10,000 we are liable to have all lower frequencies present. With ordinary present-day wireless this means that we must absorb in the ether two bands of frequency each about 10,000 cycles in width, so that the total frequency band required is of a width of 20,000 cycles.

Frequency Band Required.

To transmit 20,000 "dots" per second we would require a frequency band of about 40,000 cycles, and so on. In fact, in the present state of the art, there is a direct proportion between the number of "dots" per second and the frequency band which is required. Allowing ourselves to change the time from one second, we find that *to transmit a certain number of "dots" of a picture or series of pictures the time required is inversely proportional to the frequency band.*

This general law applies so long as we restrict ourselves to one method of transmission and reception. It can be extended beyond pictures to ordinary telephony or telegraphy where we might convert the law into the amount of intelligence to be transmitted instead of the number of "dots," or the definition of a picture. Thus, to transmit a certain amount of intelligence through the ether, using present-day methods, the time required is inversely proportional to the frequency band absorbed. We must in this case take into account the method of interpretation of the signals received, for obviously these differ considerably for telephony and telegraphy. For instance, if we are allowed a frequency band of 20,000 cycles, it should be possible telegraphically to transmit about 10,000 words per minute, and by the speech or telephonic method such speeds are out of all reason.

A New Law.

There is thus at present a general law for picture or image transmission which associates the definition of pictures with the time for transmission and with the frequency bands, this law applying both to photo-telegraphy and to television. Both applications are comparatively new branches of wireless, and they are both in search of permission to enter the wireless field. Being late-comers, they find that the older users of wireless have in all countries dug themselves in, and have had allocated to themselves the right to say how wireless may be used. They have made international laws and regulations, and they keep a most careful watch on the employment of the ether, which has been divided up into frequency bands, which have already been allocated for various services. The greatest apathy has been shown by these people in control with regard to the use of the optical application of wireless, and they have only grudgingly allowed experimental transmissions.

One other standpoint that has been taken up is that the maximum frequency band that can be allowed is 9,000 cycles. This regulation applies because this happens to be the band which is never exceeded by a telephony service.

It is a very difficult situation both for the new-comers with their new optical application, and for those in control of the ether. There are many other complications which cannot be dealt with satisfactorily here. For instance, certain commercial companies who already have a licence to run wireless services can and do transmit still pictures or fascimile writing on their services. Again, the protagonists of television and some of the advocates of photo-telegraphy transmission have concentrated solely on their demand for broadcasting facilities. Still another complication is the fact that it is possible to transmit optical effects along telephone lines for newspaper and other purposes, and such lines are usually in the hands of a monopoly.

A Common Interest.

The fact remains that there is no fundamental difference between photo-telegraphy and television, as regards the basis of their technical work, their ultimate technical development, or as regards the difficulties with which they are faced in all countries. Their common interests demand that they should present a united front in their attack on the vested interests of the ether. They must realise how much they have in common, what their various possible activities are, and in this connection they should realise quite clearly that the broadcasting application is not the only one, nor even necessarily the most important; and further they must work together internationally in the one common interest in furthering the means and increasing the facilities for the complete application of optical methods to the communication field.

EXPERIMENTAL work. Inventors' models. Scanning discs any size to drawings.—JOHN SALTER, Scientific Instrument Maker (Established 1896), Featherstone Buildings, High Holborn, W.C.1.

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Noctovision and the Noctovisor

By NORMAN J. NICOLSON

In our last issue we gave some information about the recent demonstration of noctovision given by Mr. Baird at Boxhill, Surrey. In the following article our contributor gives some further technical details.

READERS of a technical journal are naturally interested in publicity accorded to any new achievements which may lie within the scope of their journal. Generally speaking, however, they are far more interested to learn something about the methods and apparatus employed in the accomplishment of these advances, and thus realising for themselves the manner in which an objective, hitherto deemed outside the realm of practicable possibilities, has been brought within the boundary by the patient endeavour of some inventive genius or scientist.

Most subscribers to this magazine will have perused recent accounts relating to Mr. Baird's latest development, christened the Noctovisor; an invention providing us with an instrument by means of which, in the densest smoke or fog, lights may be located at distances upwards of several miles and their bearings accurately recorded.

Obviously a valuable application this is for ships at sea, to enable navigators when blanketed by fog to maintain their courses with a larger measure of security against collision of running their vessels ashore; and in fact the instrument was evolved with this aim in view. Having been privileged to gain an insight into the mysteries of noctovision and its offspring, the noctovisor, we shall attempt to enlighten others who are similarly intrigued in a "how-on-earth-is-it-done" sense.

It is well known in scientific circles that ether waves or rays produce different effects and require various means of reception, according to their frequency. Energy is conveyed by all of these waves and can be made perceptible as heat by using suitable detectors.

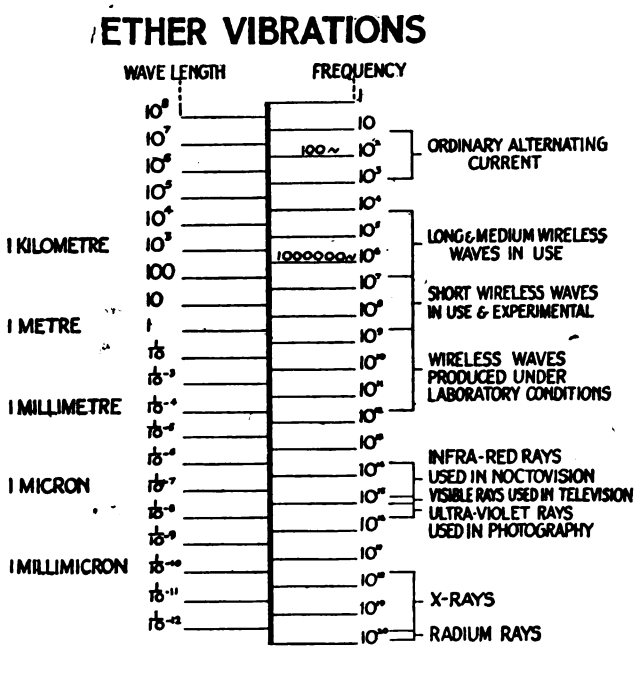

Fig. 1.

Table of Ether Vibrations, with frequency per second and equivalent wave-length in metres.
It will be noticed what a small section the visible spectrum is composed of, even compared with the infra-red; also considerable amount of unused and in some cases uninvestigated sections still remain.

In noctovision we are not concerned with those vibrations known as the visible spectrum, but with a band of rays just below, scientifically named infra-red, of which our bodies are made aware when we feel radiant heat—such as sunshine. It is these rays which warm us and make us sunburnt. In fact most of the sun's energy reaches this earth in this form. Scientists originally proved the existence by the aid of thermometers,* but although unseen their presence may be easily detected in a number of ways.

Now, the visible rays—violet, blue, green, orange, and red—are more or less easily absorbed by fog, the violet far more so than the red. Thus readers who live in foggy towns will, if ordinarily observant, have noticed that red electric signs are seen much more brilliantly on foggy occasions than are, say, blue or white signs. That is the main reason why, with road warnings and in buoyed channels, we find red the predominating illuminant. If the fog is very intense all lights are blotted out, as we know, and at sea even the most powerful lighthouses are rendered completely invisible to the eye except at very short distances, so that until the advent of noctovision and its adjunct, the noctovisor, the modern navigator was no better able to pick up visual navigational warnings under such conditions than were the early Britons able to see their countrymen's warning fires on distant hilltops.

Fog has practically no absorption effect on infra-red rays, so that, given

*See "Invisible rays—the infra-red." TELEVISION, No. 2, April 1928.

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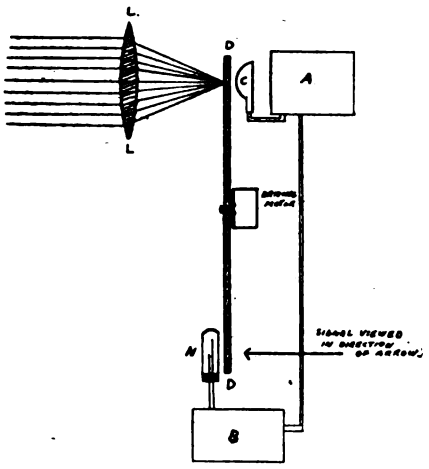

Fig. 2.
Schematic layout of Noctovisor.

some device for rendering invisible rays visible to the human eye, use may be made of such penetrative properties as they possess, to assist us in thick weather. Noctovision owes its existence to these properties and might well be termed "infra-red television," because we apply the usual television methods of reproduction, merely substituting infra-red rays for those of the luminous spectrum.

Derivation of Noctovision.

Students of etymology may possibly disagree with the designation "noctovision" as a suitable *nomen* for this discovery. Being derived from the Latin *noctes*, meaning night, and *videre*, to see, noctovision consequently is "seeing by night," which perhaps is not altogether correct, seeing that with infra-red rays we look through fog and smoke whether it is night or day. This, of course, suggests more than a suspicion of hair-splitting and is merely a thought *en passant*.

As in ordinary television, the first link between light and electricity in noctovision was the selenium cell, but for the same reason that it had to be discarded in television experiments, i.e. on account of its inertia or time-lag, so it was found useless for noctovision and has had to give way to the photo-electric cell. The earlier photo cells were also far from suitable for the purpose of responding to infra-red rays owing to their abnormal sensitivity to the blue rays. However, research workers quickly produced cells of a different type which would give their maximum response to infra-red, and these, though still capable of improvement, are found sufficiently good to achieve satisfactory results. The blue sensitive cells are the potassium kind, and in the red-sensitive category we now find ourselves with a choice of several, such as rubidium, cæsium, hydrogen, and thallofide. Our old friend selenium has almost completely receded into the background except in certain light-controlled switchgear where extreme rapidity of action is not essential.

Infra-red rays are present in most sources of illumination, and the method of separating them from the luminous portion is to place an absorption filter in the path of the light, so designed that it will only pass these rays. A thin sheet of ebonite effectively fulfils this purpose.

Mr. Baird, years ago, found that he could televise persons seated in total

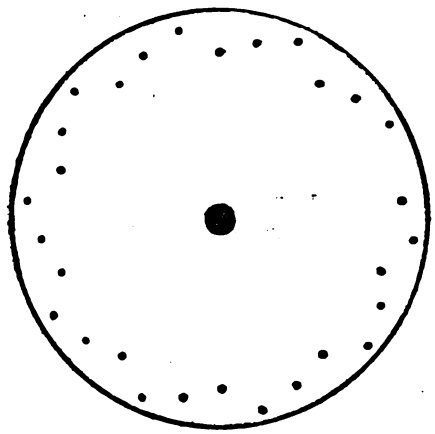

Fig. 3.
Diagram of Noctovisor disc.

darkness by means of infra-red rays by the aid of his scanning devices and either spot or flood lighting, but, as with other of his valuable discoveries, the matter then became more or less shelved until the scope of its application seemed clearer. Now the principle has re-emerged from its comparative obscurity in the shape of the Baird noctovisor.

Its construction is in accordance with the theoretical layout shown in Fig. 2, where *L* is an ordinary convex lens which concentrates an image of the radiating light point on to a perforated disc *D*, to the rear of which is situated a red-sensitive cell *C*, connected up to an amplifier *A*. The output of *A* is in turn connected to the input of an additional amplifier *B*, which operates a neon lamp *N*. The light is received at the top of the disc and may be viewed simultaneously in the screen formed by the neon at the bottom, 180° opposite to the cell mounting. There being no definite image formed, as we shall see later, it is unnecessary for the scanning direction at the receiver side to be the same as at the transmitter.

Considerations of Disc Design.

We must now study the disc itself. Before explaining the way in which this is perforated let us examine the requirements. A finely detailed picture of the light point is, of course, unnecessary, it being sufficient to know that it is there and to be able to take its bearing. What we do want is that our apertures shall be as large as possible in order to admit as much of the light, or its infra-red component, as we can to the cell, for upon the amount of ray admitted depends the range of the noctovisor's operations. So it is permissible to use large perforations and a coarsely-grained screen.

We must naturally have a continuity of apertures around the disc, and also the diameter of this cannot fall below a certain size owing to two further considerations. Firstly, one needs to be able comfortably to view the screen below, and, secondly, the neon cannot be mounted within a certain distance of the photo-cell, else, despite all precautions, the latter will pick up the quite appreciable radiation of the former and cause oscillation in the amplifiers, just as

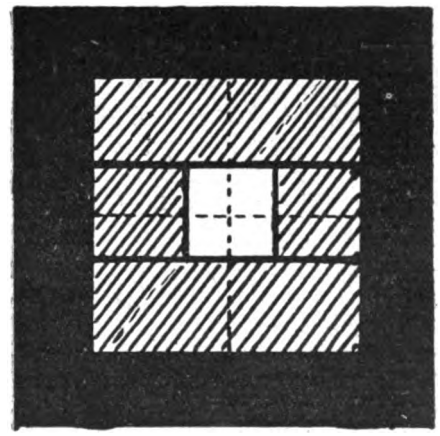

Fig. 4.
Diagram of Noctoscope viewing aperture. The spot of light is first picked up anywhere within the black frame and by suitable adjustment of the sighting controls is brought to the centre, where it is indicated as a white spot.

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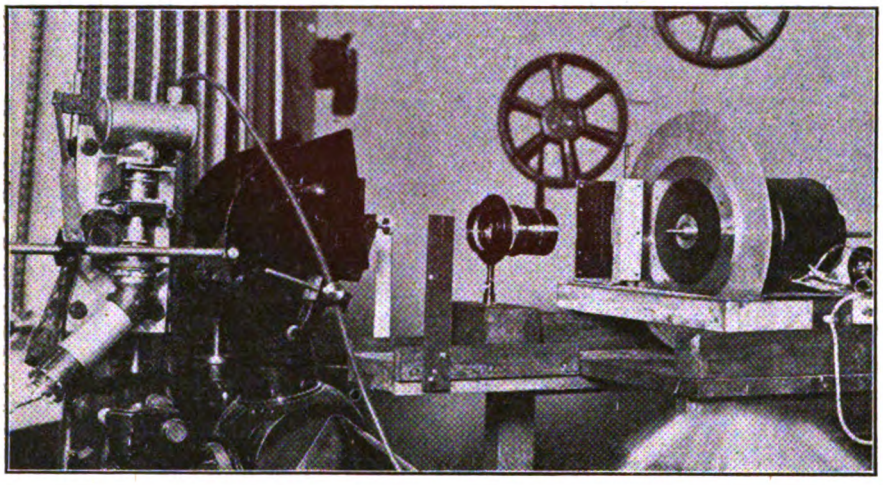
any amplifier will oscillate when coupling exists between its output and input.

The disc eventually decided upon as suitable (although its design is not by any means arbitrary) was a thirty-hole disc with round apertures arranged in ten series of three, as shown in Fig. 3, the diameter of each being $\frac{3}{8}$ in. Considering that the grain of our screen consists of but three strips, and each disc revolution produces this ten times, the driving-motor, in order to maintain a continuous image, need not rotate faster than 70 to 80 revolutions per minute. But another point enters here, for which allowance has to be made, and that is the low-frequency response of our amplifier. At 80 revolutions our minimum frequency, when a light signal is present, could be as low as $\frac{10 \times 80}{60} = 13{\cdot}3$ per second, and this would present a delicate amplification problem. Our disc speed then has ultimately to be governed by the characteristic of our amplifier. The writer is not at liberty to divulge circuit details of the noctovisor amplifiers, but it is sufficient to say that they contain several unique features. The neon is coupled so that it glows only when a signal is recorded. Thus the light is seen on a black background, not a pink one, as would otherwise result.

Following through the operation of picking up a light from its infra-red radiation with the noctovisor, the lens concentrates the image of the light on the disc, which scans it with its series of three holes passing the direct values of the ray on to the cell, which converts the ray impulses into electrical impulses. These are amplified and set up large current fluctuations in the neon, which can be quite easily noted by anyone looking at that portion of the disc in front of it. The whole unit is mounted on a base calibrated in degrees, and can be swivelled round and elevated to meet requirements.



THE BAIRD TELE-TALKIE TRANSMITTER.

On the left is the film projector, which throws an image of the picture on to the face of the scanning disc at the right. Behind the scanning disc, and not visible in the picture, is the photo-electric cell.

When we wish to ascertain the presence of a light all we have to do is to manipulate the noctovisor like a telescope until the light appears in the exact centre of the viewing screen (denoted by a vertical hair line). Consult the scale below and we have its bearing.

Equally Suitable for Daylight Use.

If the light were stationary, as in the case of a lighthouse, its exact distance from a moving vessel could be plotted in the usual navigating manner—by triangulation. A navigator picking up a moving light in his noctovisor during fog would simply alter his course as required. A natural query to raise is whether the instrument functions equally well during fog in daylight. The answer is yes. The internal arrangements are such that the noctovisor ignores an even daylight signal and is sensitive only to points of light whose intrinsic brilliance is greater than their background of daylight. Ordinary ships' masthead lights quite easily fulfil this condition.

A secondary use for the noctovisor (but nevertheless one that has obvious potentialities) is that it might be utilised for secret morse signalling between two points where the flashing of visible lights would be a disadvantage.

Before concluding, one might hint at the future trend of progress and further beneficial innovations likely to accrue from noctovision.

It is quite a feasible proposition technically and one which would, no doubt, prove invaluable during a period of hostilities to use infra-red searchlights to sweep the skies or seas and to view, instead of the direct rays, those reflected back from any objects in the path of the infra-red searchlight. These searchlights might be used to detect aircraft, ships at sea, and even land forces at night or in fog, without conveying any warning to them that they were seen. An earlier materialisation of this idea will undoubtedly appear shortly to enable icebergs to be located in fog.

Noctovisor *versus* Direction Finder.

Doubtless many interested readers will be inclined to wonder whether the noctovisor has arrived too late, in view of the parallel service it affords to wireless direction-finding? The writer offers a decidedly negative opinion to this query. Wireless direction finders are admittedly superior over distances exceeding the limits of direct human vision, but even so, they are subject to certain freak effects, especially at sunrise and sunset, and in addition require a skilled wireless operator to manipulate the gear. The expense of a direction-finding plant also is considerable.

Within visual limits (by this is meant distance over which one can see in clear weather) there is no doubt that the noctovisor will prove a greater asset to ships than their direction finders. Equipped with this instrument, all existing lighthouses and buoys would, in foggy weather, be visible to them at their usual distances, and a navigating officer could operate it with ease. Naturally, any navigator would prefer to be guided by lights at close range than by bearings which he must trust blindly and apply in conjunction with his chart, the leadline, and the roughly calculated speed of his vessel.

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Television at the Berlin Radio Exhibition

by

THE EDITOR

IN the *Evening Standard* the other day "The Londoner," in his diary, deplored the apathetic attitude of British business men towards new ideas and inventions. He cited the case of two scientist-inventors who had attempted to interest British manufacturers and financiers in their work, only to be told frankly that their only chance of success was to go to Germany.

"The Londoner's" paragraph attracted my attention more particularly because I had just returned from a visit to the great German Wireless Exhibition in Berlin, where I noted an atmosphere of perpetual alertness for new ideas not only on the part of business men, but also amongst government officials.

In Germany, as in this country, the government controls wireless broadcasting, but there the resemblance ends. In Great Britain there is no visible evidence that the government is even aware that the wireless industry exists; it certainly takes no steps to help, or even co-operate with the trade. In Germany the government is so anxious to help the wireless industry that it may almost be said to father it.

Government Interest.

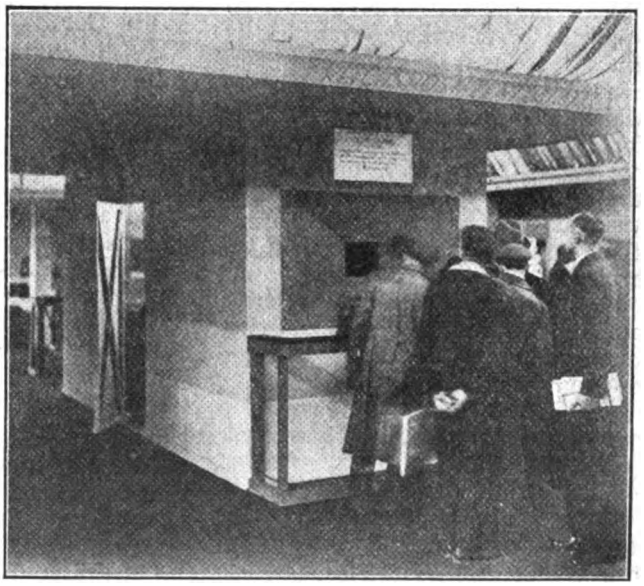
Every year, at the Berlin Wireless Exhibition, the Reichspostzentralamt (G.P.O.) takes a considerable amount of space which it devotes to exhibits which are calculated to assist the German wireless industry in some form or another. Last year space was allocated to the demonstration apparatus of the two television workers who were then active in Germany, Professor Karolus, of Leipzig University, and Denes Von Mihaly, of Budapest. Mihaly, although not a German citizen, has received subsidies and every other form of assistance from the German government.

Within the last few months, as has been chronicled in the pages of this journal, a deputation of German government officials, headed by Dr. Hans Von Bredow, who is the Czar of broadcasting in Germany, came over to England to investigate the Baird system of television, with results which are already known to my readers. At this year's exhibition more space than ever was devoted by the Reichspostzentralamt to television demonstrations. In addition to the systems of Baird, Karolus, and Mihaly, the Post Office itself demonstrated apparatus.

The "Dot Theory" Again.

One of the outstanding features of all these exhibits was one which revealed that the "dot theory" of television image construction still prevails in Germany. Each exhibitor displayed a large printed card on which was given the main characteristics of his system. Amongst other particulars was given the number of "picture points" which went to form the image. The number of picture points is calculated as follows: Assuming a scanning disc containing thirty holes, and assuming that the received image is square in shape, the number of picture points is $30 \times 30 = 900$ picture points.

A thirty-hole scanning disc produces thirty strips in the image, and this method of calculation assumes that each strip is divided up along its length into thirty separate and distinct impulses or picture points. This falacy used to be very common in this country, and was continually employed by critics of the Baird system of television to prove that the



Members of the public crowding round one of the television demonstrations at the Berlin Exhibition.

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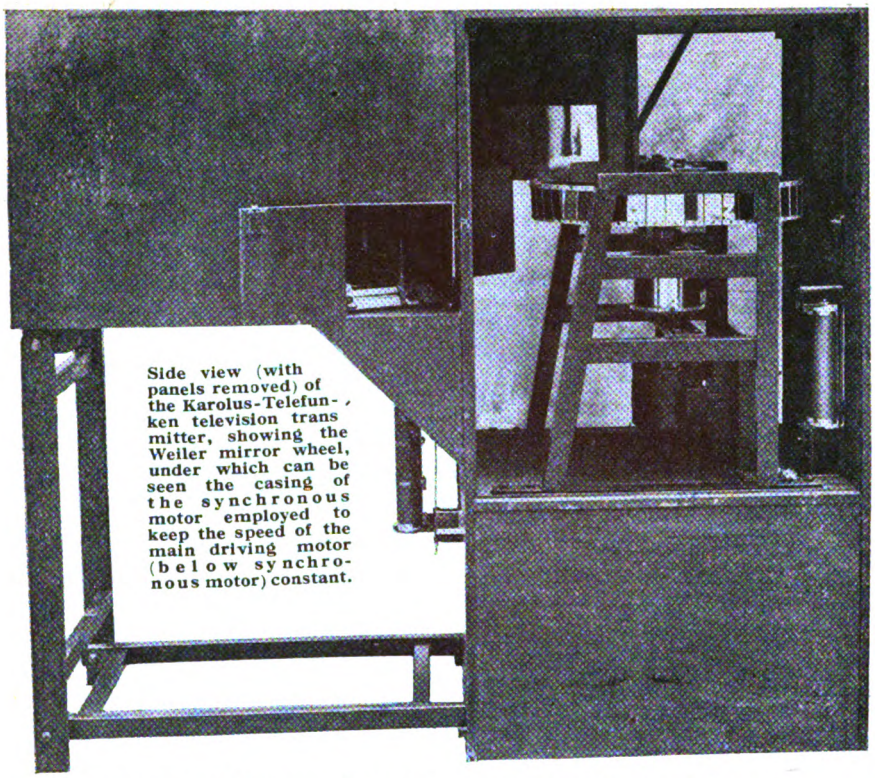


Side view (with panels removed) of the Karolus-Telefunken television transmitter, showing the Weiler mirror wheel, under which can be seen the casing of the synchronous motor employed to keep the speed of the main driving motor (below synchronous motor) constant.

frequency band width required for television was so preposterously wide that it would be impossible to broadcast television within the internationally prescribed frequency band width, for broadcasting, of 9 kilocycles.

This dot theory originated with the early experimenters in the field of photo-telegraphy, who based their theory on the points which go to make up the half-tone reproductions of photographs, such as are printed in this magazine. The theory, as applied to television, was finally and very effectively exploded in this country by the very able articles which Dr. J. Robinson wrote specially for TELEVISION.* The Germans do not appear to be very sure whether the dot theory, as applied to television, is right or not, but they argue that it is a very convenient, if arbitrary, method of giving some quantitative indication of the relative amounts of image detail and frequency band width produced by the different systems.

The Post Office receiver gave 1,200 picture points, the Fernseh receiver (representing the Baird system) 1,800 picture points, and of the Mihaly receivers, one gave 900 and the other 1,600 points. As all three used thirty-hole discs, the difference is accounted for by differences in the dimensions, or ratio of height to width, of the received image. Dividing the Post Office figure by 30, for instance, gives 40, or a dimension ratio of 3 to 4. The Karolus system gave 2,300 picture points, representing a square picture made up of 48 strips.

* See issues for November and December, 1928, and January, 1929.

Standards Chosen for Germany.

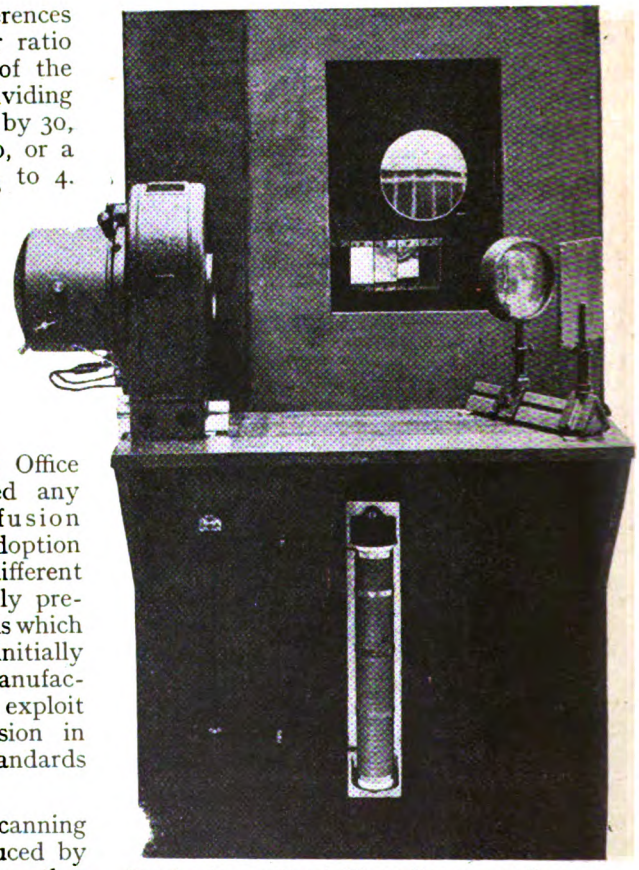
With characteristic German thoroughness, the Post Office has already removed any possibility of confusion arising, due to the adoption by rival systems of different standards, by officially prescribing the standards which must be adopted, initially at least, by any manufacturer who desires to exploit a system of television in Germany. These standards are as follow.

The number of scanning lines (whether produced by a Nipkow disc or other means) is 30. The number of pictures to be transmitted per second is 12½ (as against standard cinematograph speed of 16 per second). Horizontal scanning has been adopted, as opposed to the vertical scanning used by Baird in this country. The dimensions of the picture are to be based on the ratio 3 to 4, i.e., the picture must measure 3 units (centimetres, inches, or feet) high by 4 units wide.

The first two of these standards are based on the frequency band width available, 9 kilocycles. Worked out on the picture point basis, and considering the 3 to 4 ratio of the picture, the actual frequency, by calculation, is 7,500, or 7·5 kc.

The ratio 3 to 4 is the standard motion picture size, and has been adopted partly because it is a ratio of height to width to which everybody has become accustomed, and expects in a picture, still or moving, and partly because the German plan is to broadcast cinematograph films in the first place, during the initial experimental transmissions, and introduce actual television broadcasts gradually.

Having thus settled the ratio,



Karolus transmitter (with cowling removed) as seen from the sitter's point of view. At left is the arc lamp, at right the back of reflecting mirror and lens which directs the beam from the arc on to the mirror wheel (centre). Above the mirror wheel is the inclined mirror which reflects on to the photo-electric cell the image of the sitter. Compare these two illustrations with Fig. 2.

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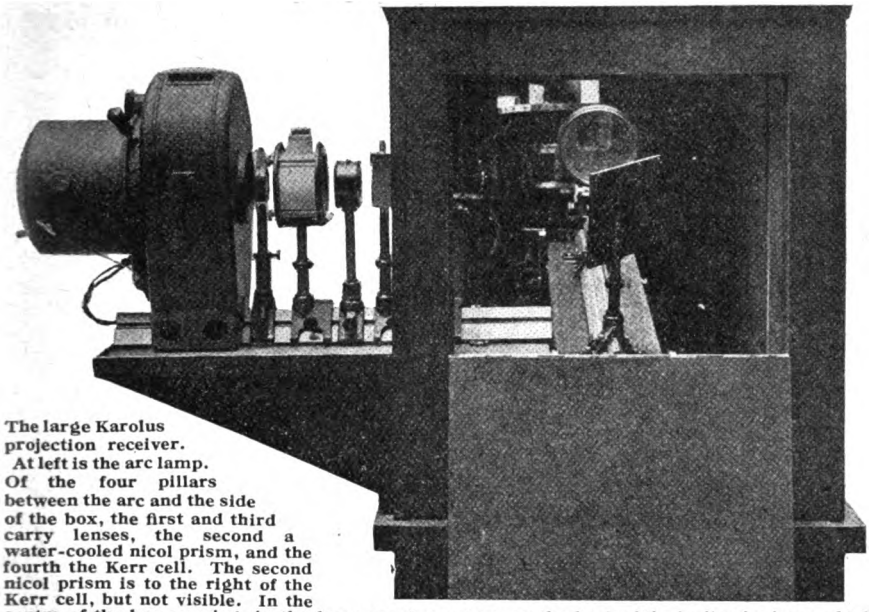


The large Karolus projection receiver. At left is the arc lamp. Of the four pillars between the arc and the side of the box, the first and third carry lenses, the second a water-cooled nicol prism, and the fourth the Kerr cell. The second nicol prism is to the right of the Kerr cell, but not visible. In the centre of the box opening, in the foreground, can be seen the back of the inclined mirror which reflects the light beam through the lens on to the mirror wheel just visible at the top.

horizontal scanning follows almost as a matter of course, for in order to obtain the greatest detail the picture strips must run the long way of the picture; to scan vertically would mean the employment of larger holes in the scanning disc, with consequent loss of detail.

Horizontal *versus* Vertical Scanning.

For television proper, owing to the limitations imposed on television at present by the frequency band width available, little more than a head and shoulder view of one or two persons can be transmitted. Now, if you consider the human face it will be realised that the most prominent characteristic lines which go to make up the features run in a horizontal direction. That being so, they can be reproduced much more clearly if they are scanned in a direction at right angles, that is, by vertical scanning.

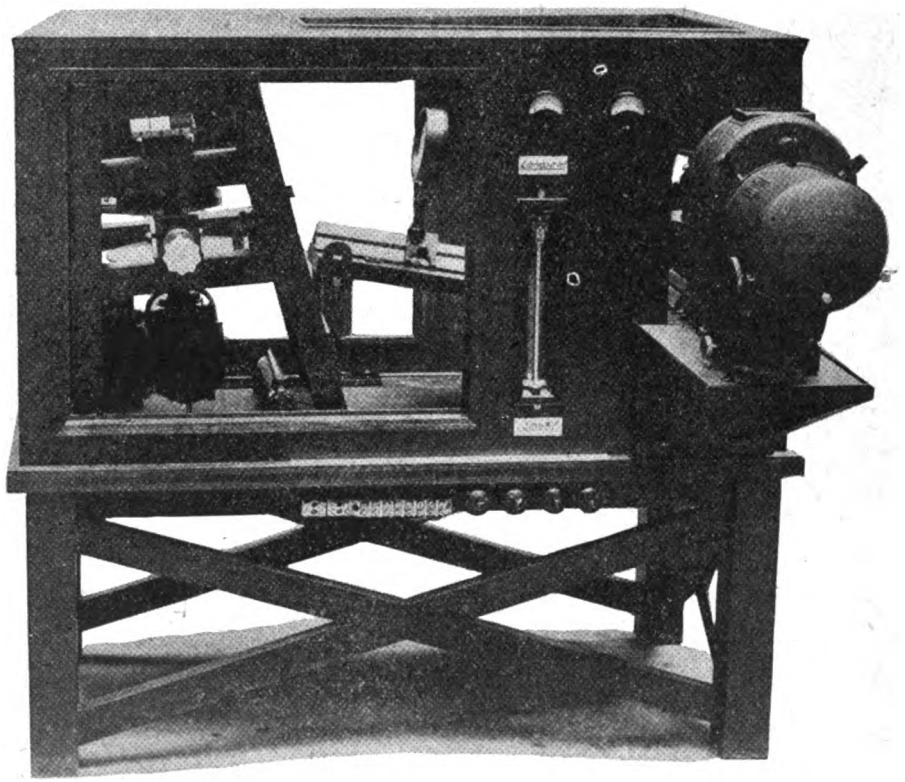
Baird states that he has found that the head and shoulders picture of a person can best be presented by a height to width ratio of 2 to 1. Of course, if the moving images of *more* than one person are to be transmitted, the 2 to 1 ratio becomes less suitable.

I had a most interesting discussion on television problems with Dr. Schroeter, of the Telefunken Company, with whom Dr. Karolus collaborates in the development of the Karolus-Telefunken system of television. As a result of this discussion, by the way, Dr. Schroeter has promised to honour our pages with a contribution on television problems.

Dr. Schroeter agrees with Baird that vertical scanning is more efficient than horizontal scanning, and drew attention to another interesting point in connection with synchronism. If the receiving motor has any tendency at all to "hunt," the movement, in the case of horizontal scanning, is to and fro horizontally; in the case of vertical scanning the movement is vertical. Now, it is a curious fact that, through long usage, we can more readily detect horizontal movement. Most movements in our everyday lives take place in a horizontal plane. We are accustomed to moving our heads from side to side rapidly. We are not accustomed to such rapid and continual movement in a vertical plane. In fact, we subconsciously oppose small vertical movements because, when we walk, our heads move slightly up and down. As a result, a given amount of hunting in a television image becomes far more noticeable and distressing in the case of horizontal scanning than it does where vertical scanning is employed. After leaving Dr. Schroeter I returned to the Exhibition and proved this for myself. It is no imaginary phenomenon, but a very real one.

The Post Office Exhibit.

Coming now to a detailed description of the various exhibits, the



A side view of the projection receiver. On the left can be seen (top) the mirror wheel, below which is the synchronising motor, and at bottom of shaft is the main driving motor. The light beam is projected from the mirror wheel upwards at a low angle through the opening in the roof of the box. Compare these illustrations with Fig. 2.

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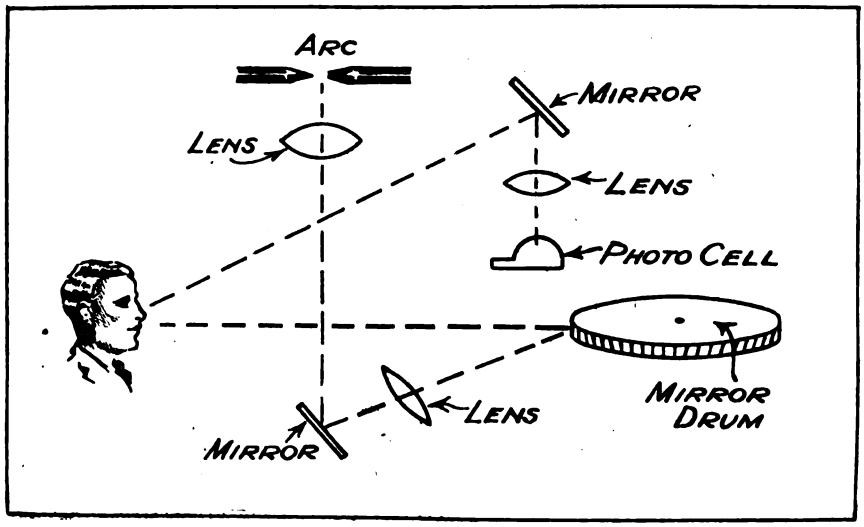


Fig. 1.
Diagram of the Karolus television transmitter.

German Post Office had a long stand divided into three compartments, all faced with large plate-glass windows, which allowed the public to see what was going on inside. In one compartment was a tele-cinema transmitter through which ran continuously a large loop of film. In the adjoining compartment was a large check receiver, on the screen of which the public could see a television reproduction of the film.

This receiver followed the design of the Baird system, but horizontal scanning was employed (as at the transmitter), and a picture was presented which was dimensioned in accordance with the 3 to 4 ratio. Instead of the usual flat plate neon tube as a light source, however, the Post Office receiver employed a rather large mercury-argon light source. This consisted of a thin glass tube bent to and fro about itself to form a grid. Between this tube and the back of the scanning disc was placed a ground glass screen to diffuse the bars of light from the grid-shaped tube. In front of the disc, nearest the observer, was placed the usual large magnifying lens.

This receiver made no pretensions to being commercial, for it was too large for home use, and the mercury-argon lamp required something in the neighbourhood of 200. watts (obtained from a large power amplifier) to operate it. The light from such a tube is bluish in colour, and the picture, though steady and good in detail, was lacking in depth and intensity of illumination.

The third compartment contained a transmitter for actual television, but it was never in operation. I was given to understand that it represented one of the Post Office's earliest efforts to build for themselves such an apparatus, and it had not proved very successful. From Dr. Bredow, with whom I had an interesting interview, I understand that another transmitter is in course of construction.

The Post Office tele-cinema transmitter, in addition to running the check receiver described above, supplied a signal which was used by all the other exhibitors to run tele-cinema receivers. In addition to the picture frequency, a separate synchronising frequency, derived from an A.C. generator coupled to the driving motor, was also sent out, both frequencies, of course, being transmitted by separate land lines. That is to say, two channels were required.

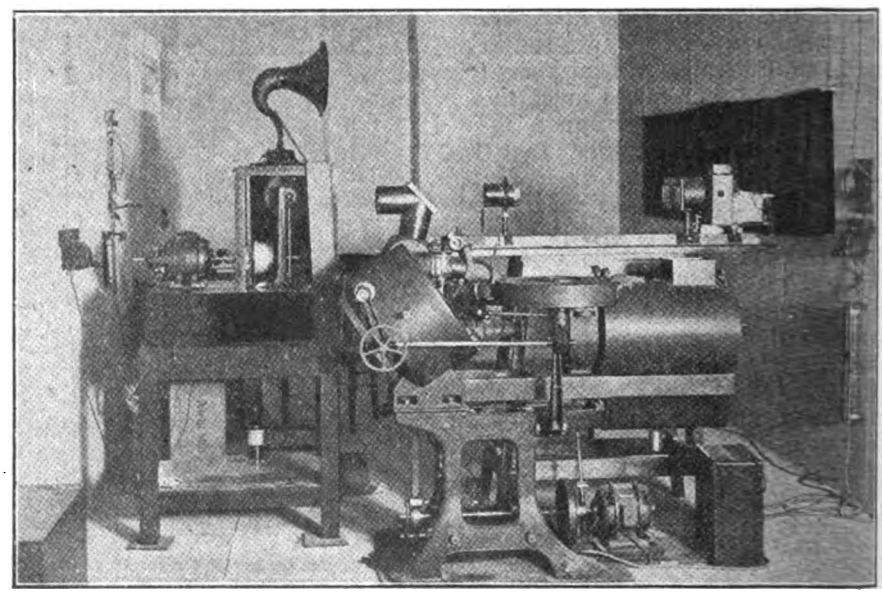
The synchronising frequency employed was 375 cycles. This was based on one synchronising impulse for each picture strip, there being 30 strips recurring 12½ times per second.

Two telephone call boxes were erected at opposite ends of the Post Office enclosure, in which a member of the public could sit and converse, by telephone, with another person seated in the other box, and see each other simultaneously. For this purpose a single scanning disc was used at each end of the circuit, so arranged that while the face of the telephonist was being scanned by a beam of light emanating from the holes at the bottom of the disc, by looking at the top of the same disc he saw there the image of the person at the other end of the wire.

The received image, however, was not at all good, and, owing to the spotlight playing on one's face, it was difficult to see.

The Karolus-Telefunken Stand.

Proceeding further round the television enclosure, we come to the Karolus-Telefunken stand, exactly opposite the Post Office stand, and equal to it in size. The main attraction of this stand was a large television transmitter, employing for scanning purposes the well-known Weiler mirror wheel device with



General view of the Karolus tele-cinema transmitter. This was not demonstrated at the Exhibition.

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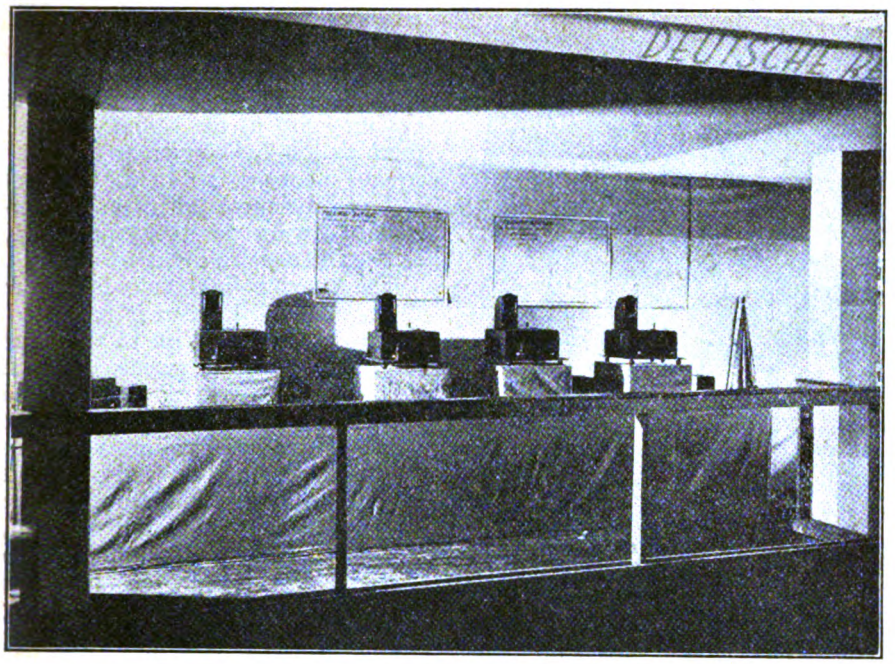

General view of Mihaly's stand. The receivers shown are of the smallest type mentioned in the text.

which Dr. Karolus has been experimenting for some time. Photographs of this transmitter are reproduced here and it is represented diagrammatically in Fig. 1.

A beam of light from an arc lamp is concentrated by means of lenses to a fine and extremely intense point, which is directed on to the revolving mirror wheel. The mirrors are set in staggered formation, which imparts vertical movement to the beam, while the revolving motion of the wheel imparts horizontal movement.

One Cell Used.

The light point is reflected from the mirror wheel on to the face of the sitter, from whence it is again reflected and concentrated by means of a lens on to a single photo-electric cell. Baird uses two cells in his transmitter, but his spotlight is not nearly so intense. Instead of an arc he uses as a light source a gas-filled lamp of 900 watts rating. To the sitter the Baird spotlight is scarcely noticeable, whereas the Karolus spotlight shown at Berlin was uncomfortably dazzling.

On either side of the transmitter (which occupied the centre of the stand) were several Post Office laboratory models of receivers using Nipkow discs and neon tubes. These worked off the Post Office film transmission. The image they provided, however, left much to be desired, and the synchronism (by tuning fork) was definitely bad. Even when the discs were running in step they were continually going gradually out of phase.

To secure synchronism Dr. Karolus uses at the transmitter an electrically driven tuning fork that provides a steady alternating current which, after amplification, is fed to a small synchronous motor which, in turn, is mechanically coupled to the main motor which drives the mirror wheel. This synchronous motor keeps the speed of the main motor constant.

At the receiving end an exactly similar tuning fork provides alternating current for a synchronous motor which controls the speed of the motor used to drive the receiver mirror wheel. The weakness of this system lies in the tuning forks. Slight differences of temperature and other considerations cause their frequency of vibration to vary, and, of course, even the slightest variation of frequency is sufficient to upset the synchronism of the receiver. The system is also expensive, and complicated, inasmuch as the tuning forks require very careful adjustment.

The Karolus Receivers.

The main Karolus receivers, however, were housed in a separate enclosure in the centre of the television section of the exhibition. Two receivers were shown, one a small one suitable (in size) for home use, and the other a large one which projected the image on to a screen measuring about three feet square. Both of them worked off the Karolus television transmitter, although only one of them was to be seen in operation at any given time. The main synchronous driving motors of both receivers were fed from the same A.C. mains which supplied the transmitter driving motor, so that synchronism was assured without the use of tuning forks.

In the small receiver a thin pencil of light from the light source, a crater type neon tube, was focussed on to a small mirror wheel, whence it was reflected on to a ground glass screen measuring about four inches square. Owing to the large number of picture strips (48) the detail in the image was very good indeed,

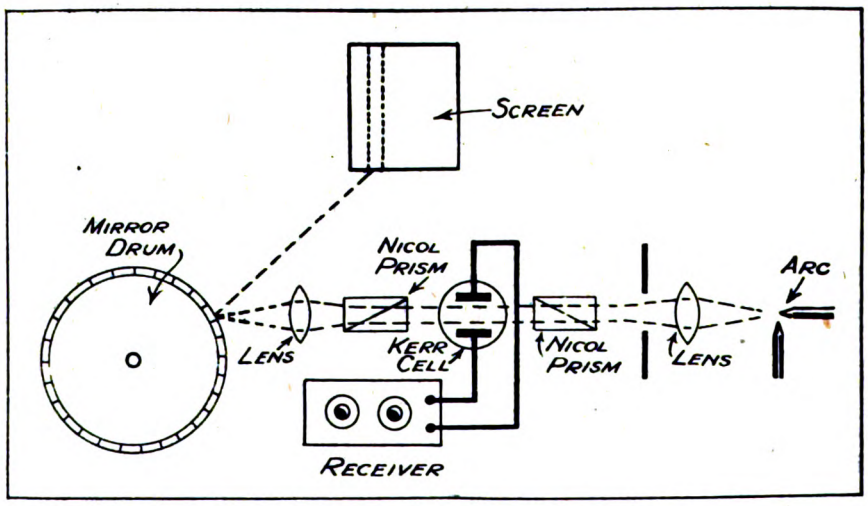

Fig. 2.
Diagram of Karolus projection receiver.

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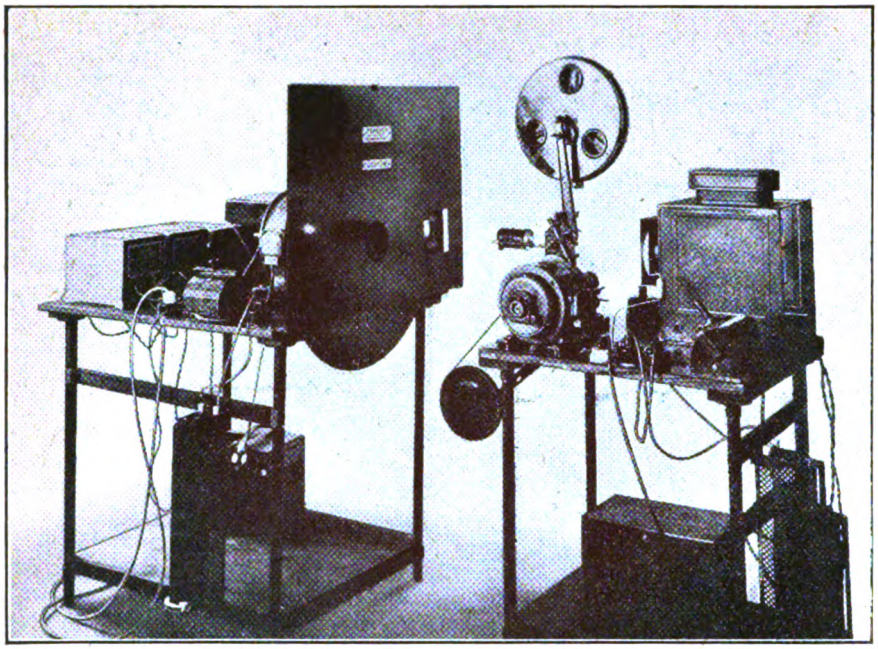

Fig. 3.
The Mihaly tele-cinema transmitter. At right is an ordinary cinema projector, which projects the moving picture on to the scanning disc (left).

but no better than Baird obtains by using, in his 30-hole disc, the very small holes which are made possible by the choice of a 2 to 1 picture ratio.

Dr. Karolus's choice of ground glass to act as a translucent screen can scarcely be called a happy one. Not only did the ground glass limit the illumination, but it caused it to

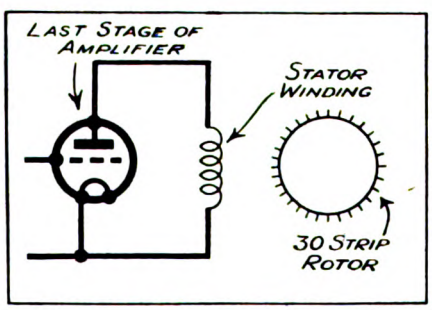

Fig. 4.
Diagram of Mihaly phonic wheel drive circuit.

be very directional—that is to say, if you stood in such a way that your eyes were dead level with the centre of the screen you could see the middle of the image quite clearly, but scarcely anything of the edges. In order to see the edges you had to move your head bodily from side to side and up and down.

Photographs of the large receiver accompany this article, and it is shown diagrammatically in Fig. 2. Light from an arc lamp is concentrated to pass through two sets of nicol prisms between which is situated a Kerr cell. As is well known, the action of a nicol prism is to polarise light, *i.e.*, cause it to vibrate in one plane only instead of in every conceivable plane. The first prism polarises the light beam in one plane, while the second prism polarises it in the opposite plane, the net result being that the light vibrations in the two opposing planes cancel each other, and no light at all emerges from the second prism.

A Kerr cell consists essentially of two small condenser plates immersed in nitro-benzol. The light beam, polarised in one plane only, passes between the condenser plates, which are connected to the two output terminals of the television signal amplifier. The effect of these varying electrical impulses is to depolarise the light beam, so that, according to the intensity of the signal currents, more or less light emerges from the second nicol prism. In the Karolus receiver the nicol prisms are water-cooled, owing to their proximity to the intense arc light.

The varying light emerging from the second nicol prism is projected, by means of a lens, on to the large receiving screen, the surface of which is covered with very finely powdered aluminium, like a cinema screen. The detail of this large picture was very good indeed, but extremely difficult to see, as the illumination of the screen was very poor indeed. Dr. Karolus, who was kind enough personally to explain his apparatus to me, told me that I was looking

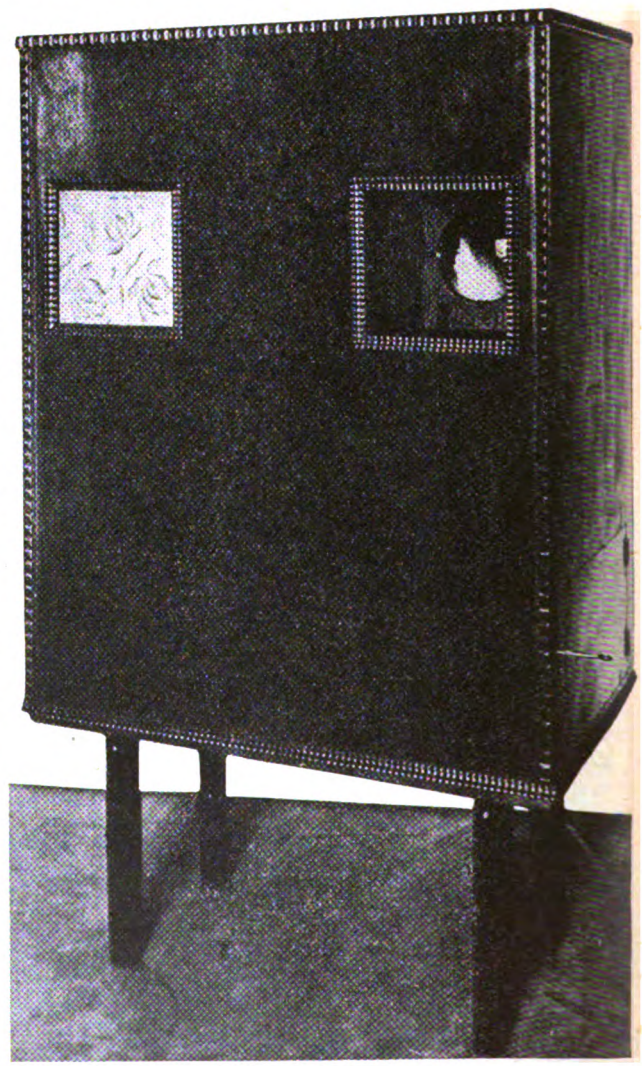

Fig. 5.
Large Mihaly receiver. The image appears at the right, while on the left is a loud-speaker, as in the Baird receiver.

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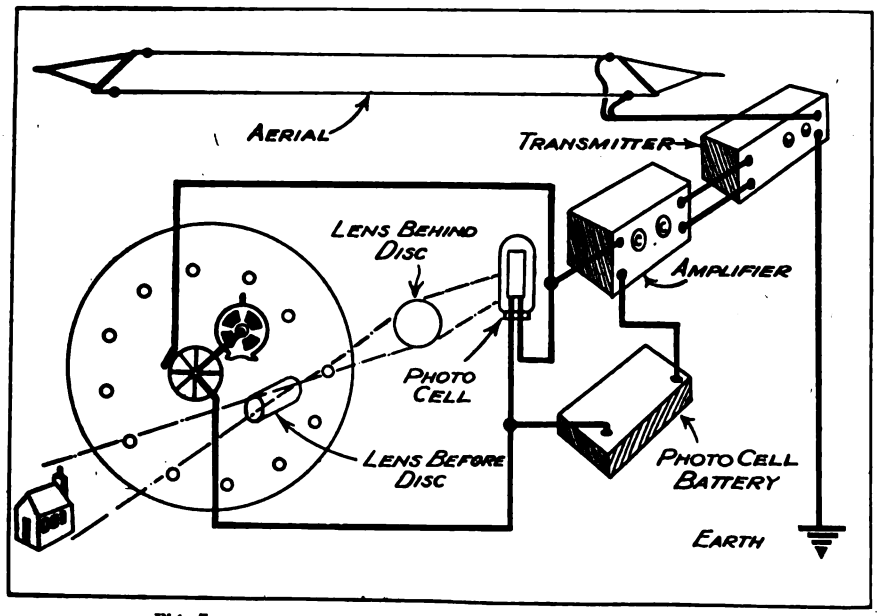

Fig. 7.
Diagram exhibited by Mihaly to explain his proposed automatic synchronising system. See text for explanation.

at the large screen under adverse conditions. Although the television section was illuminated only by very subdued lights, there was still sufficient light left to be prejudicial to the Karolus projection screen. Dr. Karolus assured me that, seen in total darkness, the large screen image appeared very well indeed. Unfortunately, I had no opportunity to view it under such perfect conditions.

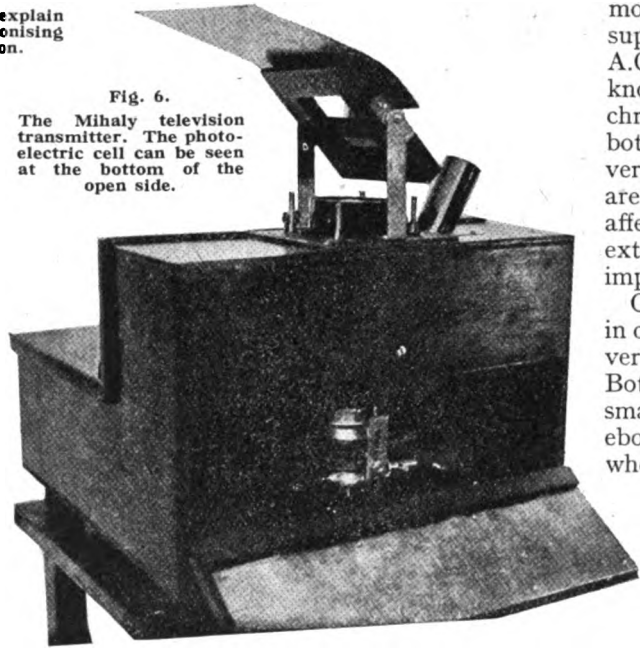

Fig. 6.
The Mihaly television transmitter. The photo-electric cell can be seen at the bottom of the open side.

The Mihaly Stand.

Coming now to the Mihaly exhibits, I found the young Hungarian inventor very annoyed with those of his critics who in the past have, in the absence of authoritative confirmation or personal demonstration, doubted his many claims. Naturally, responsible scientists, journalists, and other interested persons are not prepared to accept mere claims which are not backed up by conclusive proof. In the past Mihaly has been, and still is, very widely discredited because of his disinclination to give demonstrations or produce patents which would prove the worth of his claims. Through an interpreter he expressed to me the view that his word should be sufficient, and that it was not fair to insist that he should disclose his latest methods and achievements. As a responsible editor, therefore, I can only give here such technical details as Mihaly told me about his system, and describe what I actually saw.

Mihaly worked for many years using tiny mirrors operated by oscillographs for scanning purposes. About two years ago, seeing the success which Baird was achieving by using the Nipkow disc for scanning purposes, he too turned to that means. All his apparatus at Berlin worked on the Nipkow disc principle.

New Arrangements.

Last year he was using as a light source for the receiver a special high frequency "Wolfram" lamp. This year he is using flat plate neon tubes. Only recently he was announcing that he proposed to secure synchronism by using, both at the transmitter and at the receiver, synchronous motors driven by alternating current supplied by the standard German A.C. supply net. Now, it is well known that such a system of synchronism will work very well when both transmitter and receiver are in very close proximity, but when they are remotely separated local influences affect the A.C. supplies to such an extent that accurate synchronism is impossible.

On the Mihaly stand were to be seen in operation two types of receiver, one very small, and one somewhat larger. Both are illustrated here. The very small receiver consisted of a light ebonite disc driven by a small phonic wheel, the stator of which was supplied with current from the same A.C. mains which supplied the transmitter. The number of holes in the disc was twelve. The light source was a small neon tube which, I

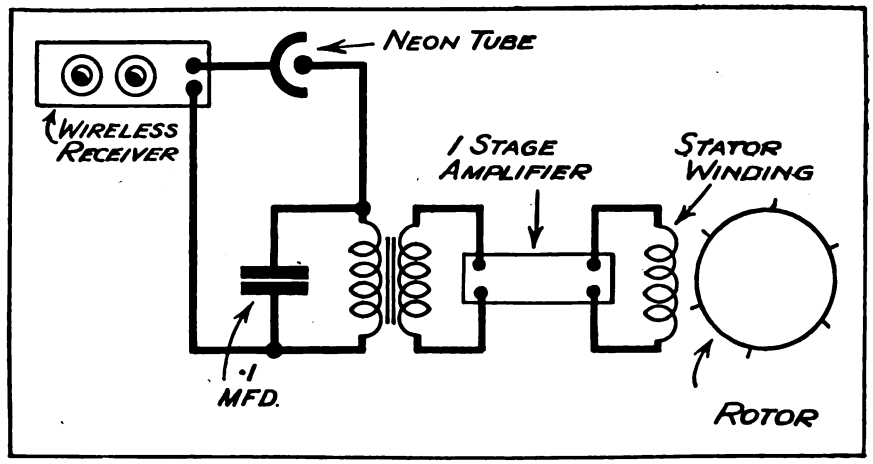

Fig. 8.
Diagram of circuit arrangements at receiver when the Fig. 7 system of synchronising is employed.

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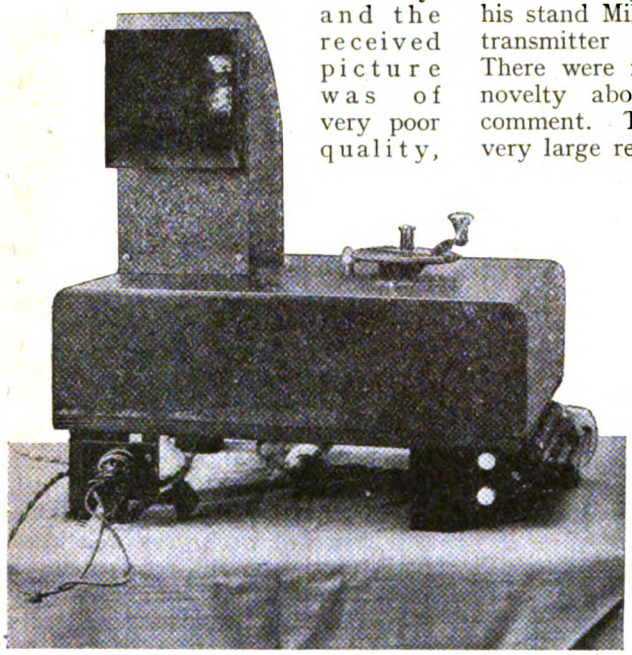
was informed, consumed only 10 Ma. This receiver was fed from a transmitter, similar to that illustrated in Fig. 3, which was located in the cellar of the building. The transmission consisted of the image of a lantern slide only, and the received picture was of very poor quality, due to the small number of image strips.



The second type of Mihaly receiver mentioned in the text. A motor of the phonic wheel type is not self-starting, so the handle (rubber band, friction-drive coupled) is provided so that the user can bring the disc up to speed when starting. The resistance for rough speed adjustment is visible at the right.

Receiver Details.

The larger receiver, somewhat better constructed, is illustrated here. The disc, in this case a 30-hole one, was also driven by a phonic wheel, used as an induction type synchronous motor, the rotor of which contained 30 iron strips. The stator was supplied from the output terminals of a three-stage amplifier, the input terminals of which were supplied by the 375 cycle synchronising current sent out by the Post Office tele-cinema transmitter. The circuit connections to the phonic wheel are given in Fig. 4.

The voltage on the last stage of the amplifier was 150-200, and the output current 30-40 Ma. In series with the stator winding was a variable 1,200 ohm resistance for rough speed adjustment. I was told that the phonic wheel would run on 8 watts, but not very well. The resistance was generally set to supply the wheel with about 12-14 watts.

The neon tube employed consumed 50-60 Ma., and was, of course, supplied by another amplifier whose input was the picture frequency sent out by the Post Office transmitter. The reproduction of the Post Office film on this receiver was quite good.

Behind a partition at the end of his stand Mihaly had a tele-cinema transmitter of his own working. There were no technical points of novelty about it which require comment. This transmitter fed a very large receiver (standing about six feet high) in a second enclosure similar to that used by Karolus. This receiver is illustrated in Fig. 5. Vertical scanning and a large neon tube were employed. The disc, measuring about three feet in diameter and containing 30 holes, was driven off the A.C. mains by a synchronous motor which appeared to be of about ¼ h.p. rating. According to Mihaly, no other means of obtaining synchronism could be employed in such a large machine.

The picture produced by this machine, as seen through a magnifying lens, appeared to be about four inches square. The brilliancy of the image was good, as was also the detail. Synchronism was assured, of course, owing to the fact that the disc was driven by a synchronous motor working off the same supply as that used for the transmitter driving motor.

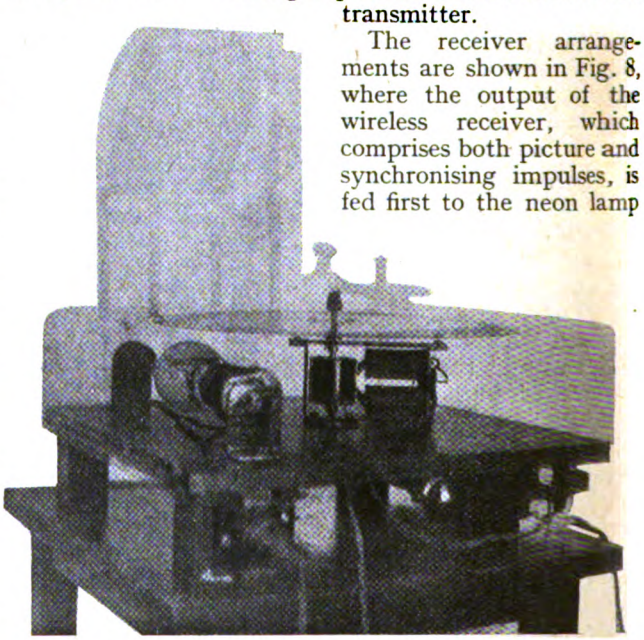
Mihaly did not demonstrate actual television, which was unfortunate. He explained that sufficient space was not left to him to install a television transmitter. However, he had two transmitters of his own in operation, one sending a lantern slide and the other a film.

His television transmitter was on view, however, and is illustrated in Fig. 6. It measures no more than about two feet long. Instead of using the spotlight principle, Mihaly told me that the person being televised sits under a floodlight, or in daylight. An image of the sitter is reflected by the inclined mirror down on to the lens, which focusses an image on to the surface of the scanning disc. Under the scanning disc is a single photo-electric cell.

Proposed Synchronising Arrangements.

Mihaly did not demonstrate automatic synchronising, but showed a diagram explaining how he proposed to accomplish it. This is illustrated in Fig. 7. A commutator mounted on the shaft of the transmitter driving motor is arranged momentarily to short-circuit the photo-electric cell six times per revolution. Such treatment is scarcely designed to improve photo-electric cells. The effect, so far as the receiver is concerned, is that six times per revolution of the disc very strong impulses are received from the transmitter.

The receiver arrangements are shown in Fig. 8, where the output of the wireless receiver, which comprises both picture and synchronising impulses, is fed first to the neon lamp and then through the low impedance primary of a special transformer. Across this primary is connected a ·1 mfd. condenser, to by-pass the



Internal view of the receiver, with phantom cover in position. The stator magnets and rotor of phonic wheel motor are clearly visible. A small knob at the front of the instrument enables the stator to be turned about the rotor for phasing purposes. The flat plate neon tube is clearly visible.

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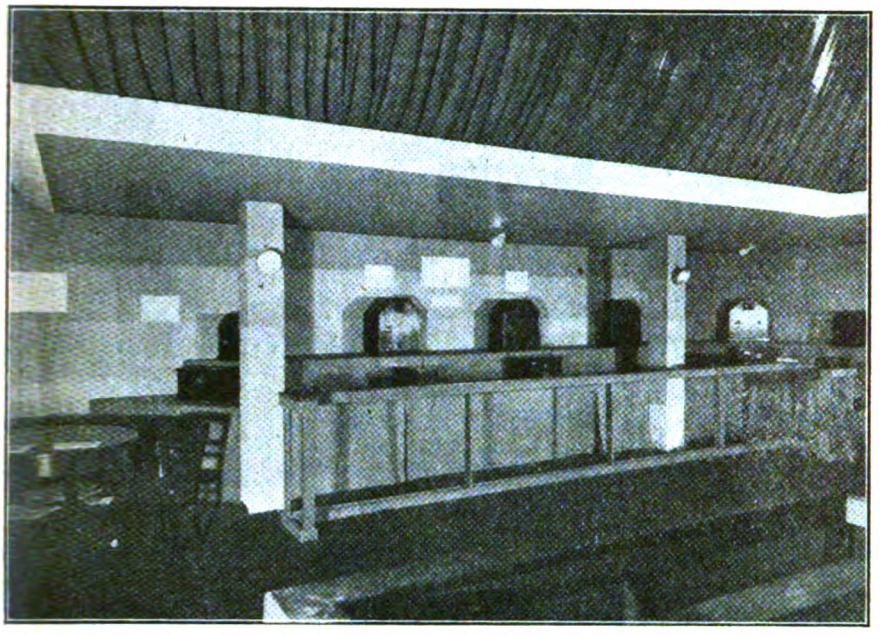


General view of the Fernseh stand.

H.F. picture component of the amplifier output.

The output of the transformer secondary is then taken to a single stage amplifier, the output of which is caused to run the phonic wheel which drives the receiver disc. I was told that a very heavy grid bias is applied to the single stage amplifier in order to rectify the synchronising impulses. Such a method of synchronism would produce a bright white strip or band either at the top or bottom of the received picture.

Fernseh, A.G.

Fernseh, A.G., my readers will remember, is the name of the company which was recently formed to develop the Baird system in Germany. The partners consist of the Baird International Television Company, Zeiss Ikon, Bosch, and Loewe Radio. This company, in the short time it has been in existence, has undoubtedly made rapid progress, the commercial aspect of which I will deal with later on.

Photographs of the Fernseh stand are reproduced here. This company exhibited several examples of the standard televisor which they intend to market in Germany immediately, but modified as regards the synchronising arrangements so that they could operate off the Post Office tele-cinema transmissions.

The synchronising arrangements of the model to be placed on the market will be adapted in accordance with the Baird method of synchronising directly off the broadcast picture signal itself. Details of the Baird automatic synchroniser are given elsewhere in this issue, so I need not describe it here.

These Fernseh instruments ran throughout the exhibition, without giving any trouble, reproducing the Post Office film transmission. As will be seen from the position of the viewing screen in the photograph of the instrument, the German standard of horizontal scanning has been adopted, as, indeed, it must.

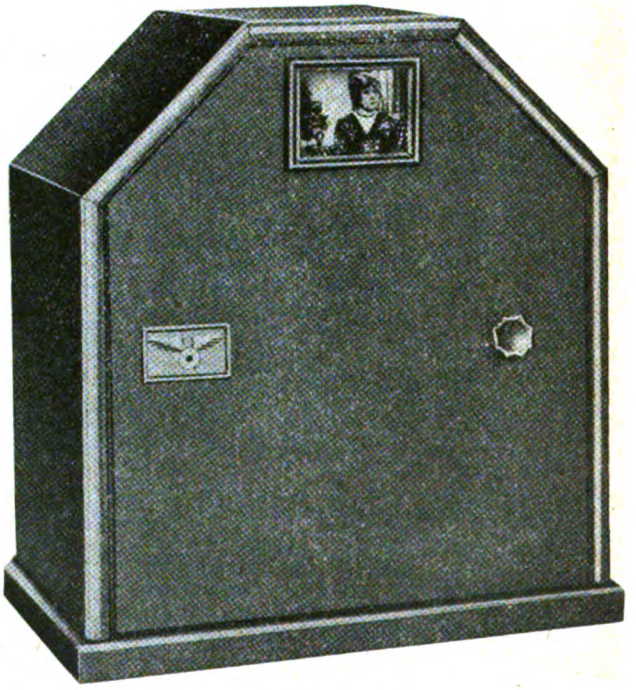
In addition to these film reception demonstrations, television demonstrations were also given on a standard Baird portable televisor, and also on one of the larger Baird machines, incorporating a loud speaker, both of which were supplied by a Baird transmitter erected behind a partition at one end of the stand. A window in this partition enabled the public clearly to see the person being televised, and compare his or her likeness with the reproduction on the televisor screens.

The Fernseh stand was under the very able and energetic charge of Dr. Goerz, who is Chairman of Fernseh, A.G., and also technical director of Zeiss Ikon. Let me give you a little pen picture of him. After the formation of Fernseh, A.G., Dr. Goerz spent *weeks* making his first disc *with the aid of a microscope*. He took charge of the exhibition stand in his shirt sleeves (the weather was very hot). He was kept extremely busy, yet everything ran like clockwork, and he always had time for courteous conversation with all comers. He never appeared to be ruffled.

I think I can safely say, without fear of contradiction, that the Fernseh stand was the most popular in the exhibition, with the possible exception of the telephone box demonstration for which the Post Office was responsible.

Comparison of Results.

Comparisons were ever odious, but my readers will naturally be most interested to know which of the various systems produced the best results. In order to compare, it is necessary, somewhere or other, to introduce a common factor. So in



The Fernseh receiver. Because horizontal scanning is employed, the image appears at the top of the disc. The knob on the right is for adjusting the synchronism.

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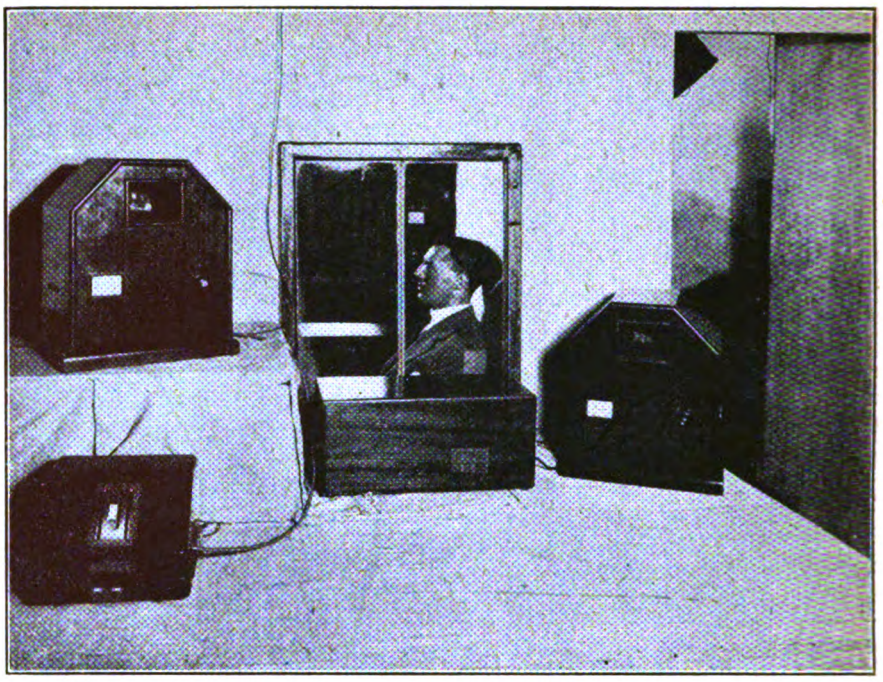
this case I will compare the systems on the results which they produced on a transmission which they all received in common, the Post Office film transmission.

In making comparisons, also, I am taking into consideration such factors as the efficiency of the magnifying lens through which the picture is viewed. If this is not correctly designed the received image appears distorted, or the angle of vision is so limited that only one person at a time may be able to see the image, and even then perhaps not clearly.

Another factor to be taken into consideration is the brilliancy of the image, upon which depends its "depth." Poorly illuminated images look like a very "thin" or underexposed photographic negative; you can just see what is there, but the richness of detail, though perhaps present, is invisible.

Judged by these standards, then, I can safely say that the Fernseh receiver gave the best reproduction of the Post Office film. Next, on the same transmission, came the Mihaly receiver. The Post Office film receivers (which, as I have explained, were laboratory setups) did not perform at all well. The distortion caused by the viewing lens was very bad, and the synchronism was poor.

I have already given my opinion of the relative merits of the Karolus and Baird television receivers, and I need only add here that whereas Baird keeps well within the 9 kc. broadcast limitation, Karolus produces a frequency of about 14 kc.



Through a window at the end of the Fernseh stand the public, while standing in front of the receivers, could see the person sitting in front of the television transmitter.

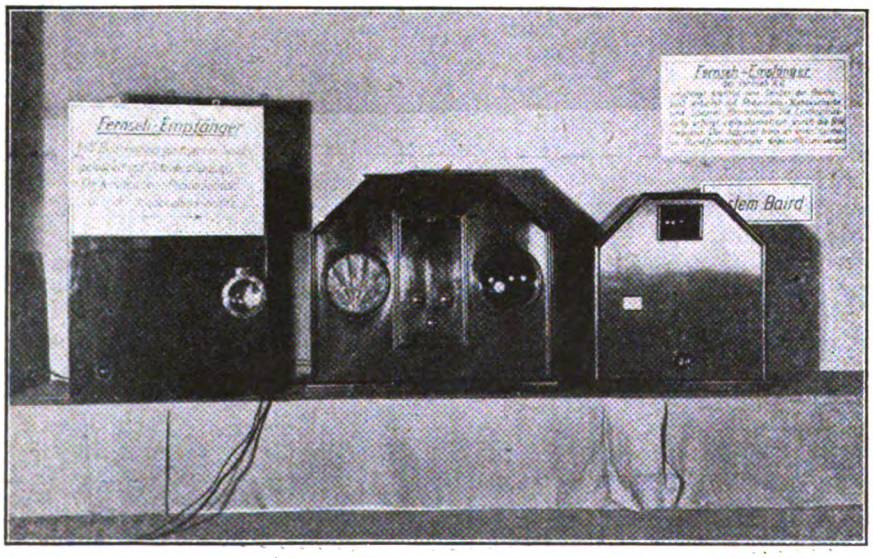
It should be pointed out that the Baird receivers were the only instruments to show successful automatic synchronism, which is imperative for any practical apparatus.

Commercial Prospects.

The commercial prospects of television in Germany look very promising indeed. The Post Office at present is engaged on building a new television transmitter, based upon the Baird system, in which will be incorporated the best practices of the various systems. This is expected to be ready by the end of October, when the Post Office will commence regular transmissions daily, from Witzleben, between 9.30 and 10 a.m., 1 and 1.30 p.m., and also in the evening at times not yet fixed. In the meantime the private experimental transmissions at present being made daily by Fernseh, A.G., and Mihaly from Witzleben will be continued.

The official Post Office transmission periods will gradually be lengthened, depending upon the interest taken by the public, and upon the progress made by those interested in the perfection, production, and sale of receivers. Dr. Bredow informed me that the intention of the Post Office, acting through the German Broadcasting Company, is to incorporate television in the regular broadcasting service forthwith.

Zeiss Lenses and Bosch Magnetos have such a world-wide reputation that the firms concerned require no introduction to my readers. Both are newcomers not only in television, but also into the field of wireless. Loewe Radio also has a world-wide reputation in connection with multiple valves. The standing of these three firms (who are the German partners in Fernseh, A.G.) is such that throughout the world, and particularly in Germany, their adoption



Left to right: Baird portable televisor, large Baird machine, and the Fernseh receiver. On the two former television proper was received from the Baird transmitter at the end of the stand. The Fernseh receiver reproduced the Post Office film transmission.

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of the Baird system of television is in itself a tremendous asset to the system. Their prestige and resources are bound to carry tremendous weight commercially, and place competitors (in Germany, at least) at a considerable disadvantage. In Germany, solid backing counts.

Dr. Goerz told me that during the period of the exhibition, without any advertising at all, he had booked orders at the stand for 100 televisors. The price of the Fernseh product has been fixed at 350 marks (£17 10s.). The production of the first 300 instruments is now in hand; they are expected to be ready early in October.

Mihaly's Commercial Arrangements.

Mihaly has granted a manufacturing and sales monopoly of his receivers to Kramolin & Co., of Berlin, a firm of wireless manufacturers. They propose at first to produce only one of the three models which I described above, the second one. They told me that, although they had received many inquiries, they had not booked any orders because, although they thought the price might be between 200 and 300 marks (£10 to £15), they had not definitely decided the point, nor were their plans complete for going into production, but they thought they would probably be ready to start production by the end of November.

In passing, Kramolin's estimate of price is of great interest, for it is but a few months ago since Mihaly was reported in the Continental and British Press as preparing to sell this identical model at a retail price of £5, both in Germany and in England.

In conversation with Dr. Schroeter I learned that the small Karolus receiver, using a 48-mirror wheel, a crater neon, and projecting on to a screen about four inches square, would cost somewhere about 700 or 800 marks (£35 to £40), complete with tuning fork synchronising gear. At present the mirror wheels are an expensive item, for the tiny mirrors have to be very accurately mounted by experts. It is hoped to cheapen these wheels by employing other methods of manufacture. I gained the impression that for the present, however, the Telefunken Company does not intend to market instruments.

Faith in Short Waves.

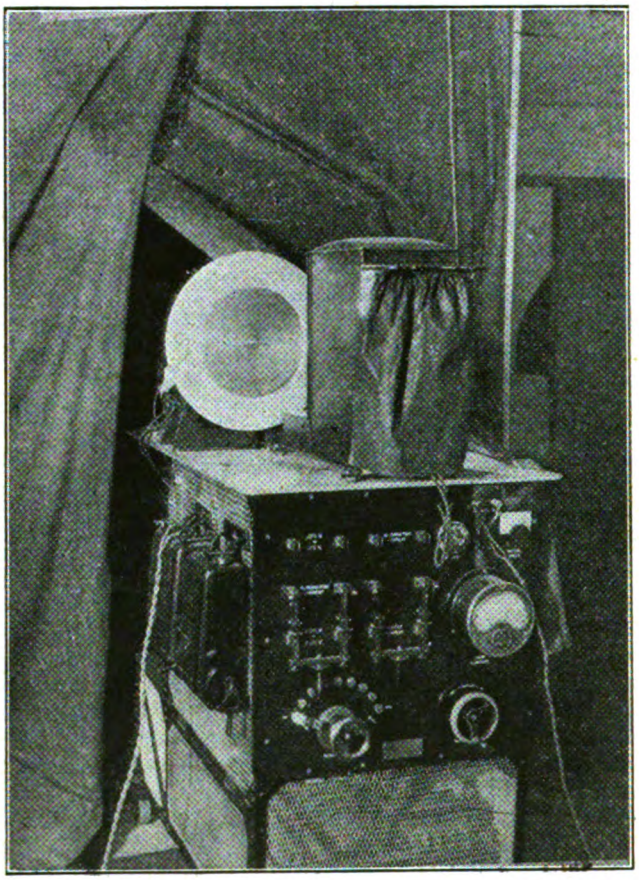
Neither Dr. Schroeter nor Dr. Karolus agrees with the standards which have been adopted by the German Post Office. They believe that greater detail (meaning more image strips and a very much wider frequency band) is necessary in order to make television a complete success. This, of course, is the academic *versus* the commercial viewpoint.

Dr. Schroeter thinks that the greatest success in broadcasting the perfected form of television which he has in mind will be obtained on short waves. The Telefunken Co. is already experimenting on wavelengths of 30 and 80 metres, using, I gathered, more than 48 image strips. These experiments, according to Dr. Schroeter, are meeting with much success.

* * *

Such is the present position of television in Germany. I came away from Berlin with the conviction that this latest adjunct to broadcasting is well launched in Germany; it is now but a matter of time and development. Public support is assured; no one could doubt it after watching for days the continual jam of people who, during a spell of the hottest of hot weather, crowded into the television section of the wireless exhibition, which, being draped to subdue external light, was, as a result, lacking in air but amply provided with degrees Fahrenheit.

The new Fernseh, A.G., may be described as being very much alert and first off the mark commercially, so that, as Britishers, we may regard the German television situation as a triumph for our own Baird system. And this triumph has been achieved within a few short months, **as a result of government enterprise and co-operation.**—*Verb. sap.*



A photograph of the Baird television transmitter showing the lantern and scanning disc.

AND NOW

having read about the Berlin Radio Exhibition

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Sept. 23rd to Oct. 3rd

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in the Gallery, where tickets are obtainable for demonstrations of Baird Television

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The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

PART X.—THE SAFETY OF LIFE AT SEA.

THE extraordinary public interest which was aroused in this country by Marconi's early experiments was not caused by any golden vision of world-wide communication for commercial gain; it was a product of the salt in our blood, a vision of the sea and of "those who go down to the sea in ships."

Wireless first came to its own as a means for furthering the safety of life at sea. It was then its most important application. It is its most important application to-day. The uttermost parts of the earth were already linked together by the telegraph, but by wireless alone has the earth been linked to the sea.

Jack Binns.

Though the importance of wireless from the shipping point of view was immediately grasped by the English people, it did not receive a really striking confirmation until July, 1909, when the liner "Republic" collided with the "Florida" in a thick fog on the high seas. The "Republic" was sinking, and plunged in darkness, the wireless cabin was splintered; but the apparatus was still workable, and the operator set an example which has been followed without a break by ships' wireless operators ever since. He stuck to his post, and by his calls for help the whole of the passengers and crew were saved. The next day that operator's name was known and honoured all over the world. His name was Jack Binns.

The next startling confirmation was when the "Titanic," with some 3,000 people on board, struck an iceberg on her maiden voyage across the Atlantic. Her signals of distress were picked up by several ships which raced to the rescue, but when they arrived, the "Titanic" had sunk, and they were only able to save some 900 persons. Without wireless all would have been lost.

The International Convention.

In the following year an International Conference on The Safety of Life at Sea was held in London. An International Convention was signed, but unfortunately, owing to the outbreak of war, it was never ratified by any of the Governments represented at the Conference. Immediately after the war, however, the British Government issued regulations which were on the general lines proposed, and other Governments followed suit with regulations which, on the whole, were less stringent than those laid down for British ships.

Another International Conference was held in London this year, and a new Convention signed which, when ratified, as we may confidently expect it will be this time, will come into force in July, 1931. It is a long document but, broadly speaking, its principal provisions are on the lines of the regulations already in force in this country, and where they differ they are better from the point of view of the safety of life at sea.

Ships' Installations.

For the last ten years it has been laid down that in general all British passenger ships, irrespective of size, and all cargo ships of 1,600 tons and upwards, must be fitted with wireless telegraphy. Exceptions are made as regards certain ships, such as short voyage ships and ships of primitive build, dhows, junks, and the like. This rule is now accepted internationally in the new Convention, as are the regulations which are in force in this country regarding the minimum technical requirements of the wireless sets installed in ships.

The main ship's transmitter must have a normal range of 100 nautical miles, that is to say, it must be capable of transmitting clearly perceptible signals from ship to ship, over a range of at least 100 nautical miles, under normal conditions and circumstances, the receiver being assumed to be one employing a rectifier of the crystal type without amplification.

There must, too, be an emergency transmitter, and both transmitters must have a note frequency of at least 100. The emergency transmitter must be placed as high above the water line as practicable, in a position of the greatest possible safety, and must be provided with a source of energy independent of the main propelling power of the ship and of the main electricity system. It must be capable of being put in operation rapidly, and of working for at least six consecutive hours. The range of the emergency

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installation must be at least 80 nautical miles for ships required to keep continuous watch, and at least 50 for all other ships, and whilst the ship is at sea the source of power must be maintained at its full efficiency.

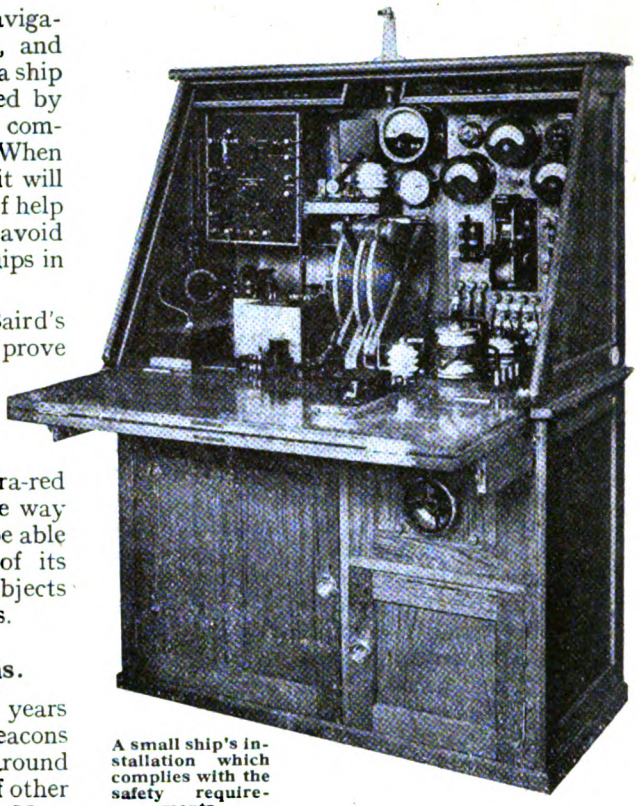
The ship's receiver must be capable of maintaining reception in emergency by means of a rectifier of the crystal type, and must be able to permit of the reception of the waves laid down for the transmission of time signals and meteorological messages.

Directional Receivers.

Within two years from the date on which the Convention comes into force every passenger ship must be equipped also with directional receiving apparatus. This is the first time that such apparatus has been made a compulsory fitting. All our large passenger ships are already fitted; in fact about 20 per cent. of our ships fitted with wireless are equipped with this apparatus, so that the new regulation will not affect us much, but it is most important from the international point of view.

Directional receiving apparatus in a ship enables the operator to obtain the bearing of the ship from any other ship or any shore station which is transmitting wireless signals, so that its importance from the safety point of view is obvious. It is of great assistance to navigation in foggy weather, and has frequently enabled a ship in distress to be located by another ship which is coming to the rescue. When more ships are fitted it will also, no doubt, prove of help in assisting ships to avoid collisions with other ships in a fog.

It is hoped that Mr. Baird's noctovision system will prove of great value in this connection later on. With this system a ship will be able to direct a beam of infra-red rays in much the same way as a searchlight, and be able to see, on the screen of its noctovision receiver, objects in the path of the rays.

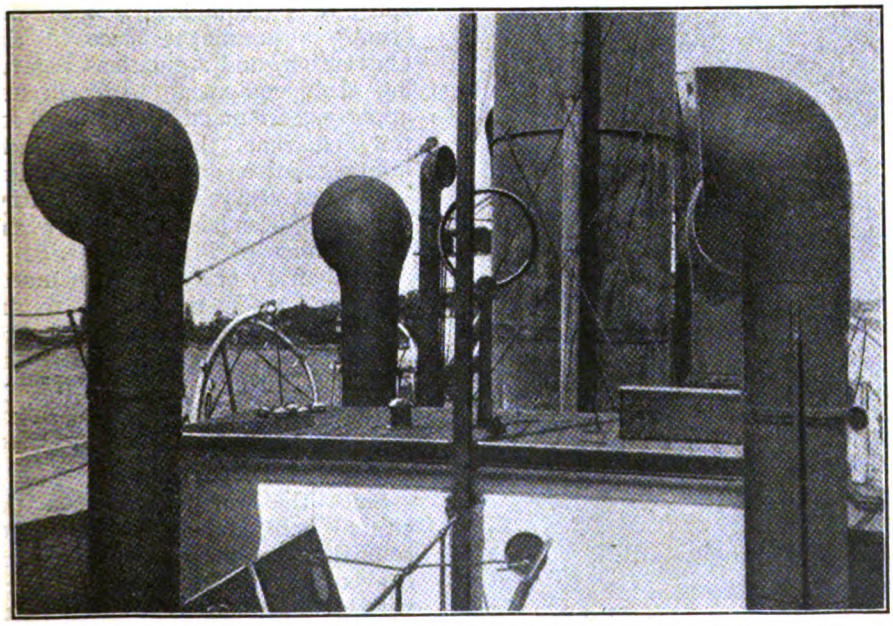


A small ship's installation which complies with the safety requirements.

Wireless Beacons.

During the last few years a number of wireless beacons have been established around our coasts, and those of other maritime countries. More than 100 are now working, and about half of these are in the United States. These beacons emit their call signs automatically at specified times, so that a ship fitted with a directional receiver can obtain a bearing on a beacon station up to a range of about 50 miles. A few beacons emit a revolving beam, which enables a ship to obtain a bearing with its normal wireless receiver, and some others emit a submarine sound signal simultaneously with the wireless signal, so that a ship may obtain not only its bearing but also its distance from the beacon.

There are, too, a large number of coast stations which are fitted with directional receivers, by which means they can obtain the bearing of a ship, and pass on the information to the ship by wireless.



The metal ring in the centre is the aerial used for the ship's wireless direction-finding apparatus.

The S O S.

The most important application of wireless in connection with the safety of life at sea is its use for the SOS signal, which is broadcast by a ship only when the ship itself is in danger. The signal consists of the three letters sent as one sign, and repeated three times. This is followed by the distress message giving the ship's position and particulars of the case of distress. Distress work is carried out on the 600-metre wave on which all ships are normally keeping watch, and all other signalling ceases as soon as the distress signal is heard. The coast stations in this country deal with nearly 100 distress cases every year.

The station which deals with the

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distress call keeps the Coast Guards, the Naval Authorities and Lloyds in touch with the situation, so that all possible means may be taken in providing assistance from the shore.

The new Safety Convention recommends that the distress signal should normally be preceded by the Alarm Signal, which is used to put into operation the auto-alarm receiving apparatus in ships in the vicinity. This apparatus is arranged to ring bells in the ship for the purpose of calling the operator to the wireless cabin whenever the alarm signal is received. Auto-alarms have been in use in many British ships for the last two years, but other countries were a little sceptical of their practical utility, and the fact that this apparatus was recognised internationally at the recent Convention ensures the more general adoption of the apparatus throughout the world. The Alarm Signal consists of a series of twelve dashes sent in one minute, the duration of each dash being four seconds, and the duration of the space between dashes one second.

Safety Signals.

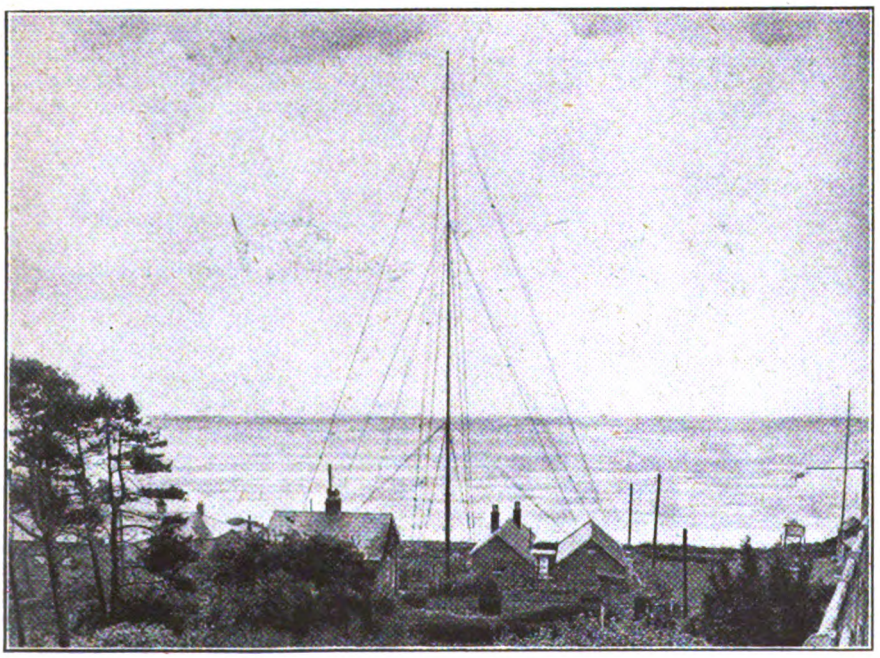
The most important signal, after the distress signal, is the Urgency Signal, which consists of several repetitions of the group XXX. This is used for urgent messages concerning the safety of ships or persons, as distinct from the SOS which is only made by a ship which is in danger.

The Safety Signal consists of the group TTT, which indicates that the message following concerns the safety of navigation, or contains information relative to meteorological warnings.

Weather bulletins, gale warnings and navigational warnings are broadcast from our coast stations. Weather reports are broadcast from the Air Ministry's station in London, and by wireless telephony from the B. B. C. station at Daventry. This broadcasting of weather reports from various stations throughout the world, is, in fact, the only use made of wireless telephony in connection with the safety of life at sea.

It is interesting to note that trials are now being made in this and other countries with the transmission by photo-telegraphy of weather charts for the use of ships at sea.

Henry Bushmeyer, the daring parachute jumper, who, while falling 3,000 feet from an aeroplane over Roosevelt Field, N.Y., described his sensations through a chin-strap microphone connected to a small portable short-wave wireless transmitter. The signals, picked up on a ground receiver, were relayed all over the United States through the National Broadcasting Company's network.



A coastal wireless station fitted with direction-finding apparatus at Niton, Isle of Wight. This station gives bearings to ships in addition to handling ordinary commercial wireless traffic.

Lifeboats.

The number and size of lifeboats, and their equipment, naturally occupy a prominent place in the Convention, and regulations regarding their equipment with wireless apparatus are made international for the first time, though there have been regulations on somewhat similar lines for several years in this country. It has now been laid down that where the number of lifeboats carried is more than 13 one shall be a motor boat, and where more than 19 are carried two shall be motor boats. These motor lifeboats must be equipped with wireless telegraphy, the range and efficiency being specified by the Administration concerned.

Inspections.

Since the war it has been the custom here, and in several other countries, to inspect ships when convenient in order to see that their wireless installations comply with their licence. All British ships which

(*Continued on page* 398.)

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MORE ABOUT NEON TUBES

By W. C. FOX

Last month our contributor dealt with the manufacture of neon tubes, with special reference to those produced by the G.E.C. This month he describes the Philips tube and gives some notes on operation.

FOR those experimenters who have made up the neon oscillograph briefly mentioned last month the following notes on the meaning of the phenomena observed may be of interest.

Using a disc and a neon tube in the manner described, one can get an approximation to the frequency of the oscillation causing the pattern, provided it is not too rapid and the speed at which the disc is rotating is known, together with the number of holes used.

Assuming the disc is making ten revolutions a second, and has ten

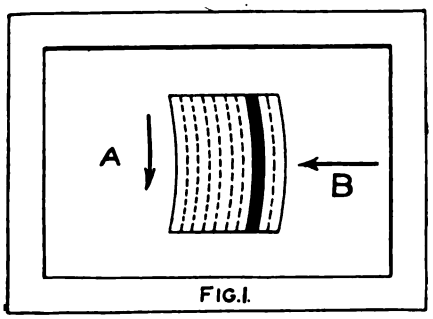

FIG.I.

Appearance of low frequency oscillation, about 10 cycles per second, on a television viewing screen.

holes and a single black band travels across each picture, this represents an oscillation of about ten per second.

Figure 1 is an attempt to illustrate this. The arrow marked "A" indicates the direction of rotation of the disc, while arrow "B" indicates the direction of travel of the band which, by the way, will be the width of one hole in the disc, whatever size that may be.

Two black bands represent 20 oscillations a second, three 30, and so on. As the frequency gets higher the bands will gradually change into longish dots, giving the draughtboard appearance of Figure 2, while at higher frequencies this will change into the curious network pattern of Figure 3, becoming finer and finer as the frequency rises. These three

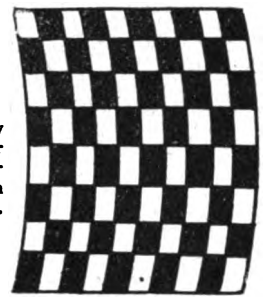

Fig. 2.

Medium frequency oscillations over 100 cycles per second, as seen on a television screen.

figures are representations of extreme conditions; between them are a great variety of forms.

The reasons for the use of neon tubes as a source of illumination for composing television images have already been given, and need not be referred to again, but a few notes on the method of connecting them to the output of the last valve in an amplifier may not be out of place.

Three main methods can be employed, illustrated diagramatically in Figures 4, 5 and 6. In each case the valve indicated is of the superpower type. Of the three methods Figure 5 is to be preferred, as it is the most stable, and gives one the greatest control over the amount of illumination given by the lamp, for it must not be forgotten that although a neon is very robust, and will stand up to almost any rough handling short of

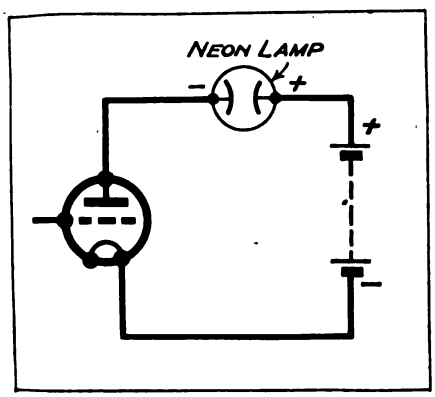

Fig. 4.

Direct method of coupling neon tube to last valve of amplifier.

breaking the bulb, it can be "burnt" out. "Burnt out" is perhaps not an accurate description, for a neon will still light in that condition, but instead of the warm, ruddy, comfortable glow of a healthy tube, one gets a sickly bluish-white type of light, and the operation characteristics are quite changed. This is mentioned because one can easily overdo the voltage. When experimenting with neons, it is better to start with a voltage which will barely glow them, and then

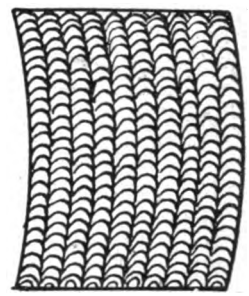

Fig. 3.

Characteristic appearance of high frequency oscillations.

gradually bringing up the brilliance by reducing the biassing voltage on the valve.

The following operation data relate to a neon tube (Figure 7) specially produced by Messrs. Philips Radio for the use of television experimenters.

It has a three-pin base (Figure 8), in which one pin acts simply as a steadying device, and prevents one getting the tube in its holder the wrong way round, a small point, but one which may cause some trouble if not noticed, for the anode (which is quite insignificant in size) will glow instead of the cathode.

This tube is of the plate type, the cathode measuring 35 by 45 millimetres (approximately 1·4 inches by 1·8 inches), one side of which is covered with an insulating layer, in order to restrict the luminescence to one side only.

The anode consists of a rectangular piece of wire of about the same size.

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An invaluable property of this new lamp is the almost absolute absence of inertia; the difference of time between the occurrence of a change

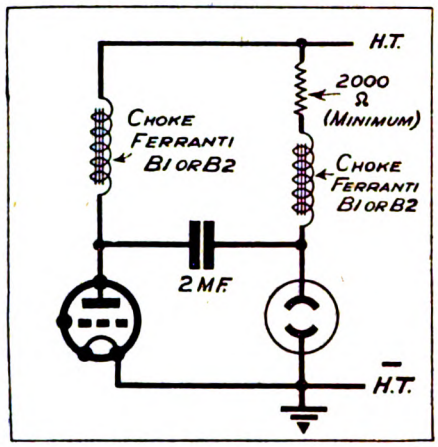


Fig. 5.
Choke method of coupling the neon tube to the last valve of the amplifier. This method is very stable and offers better opportunities of control than the direct method.

in light intensity and the current impulse which caused it being less than one hundred thousandth of a second. The overall dimensions of the lamp are 165 by 48 millimetres (approximately 6·6 inches by 1·9 inches).

Operation of the lamp depends upon the varying light intensities on the surface of the plate caused by varying current intensities.

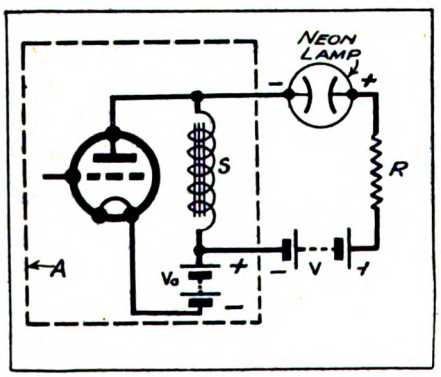


Fig. 6.
An alternative method of choke coupling a neon tube.

The entire surface of the plate should always be luminescent. This requires a minimum current of at least 4 milliamps. Similar lamps of other makes require as a rule 6 milliamps, or even more, to secure this effect. The normal current should be adjusted to 20 milliamps, so that the maximum amplitude can be 20−4=16 milliamps. When working, the current can oscillate between 4 and 36 to 40 milliamps.

When used with the choke method of coupling (Figure 6), the choke coil must have enough self-induction to insure equal voltages between the terminals for all frequencies between 50 and 10,000. The biassing voltage for the neon lamp should be 280 to 350 volts; the limiting resistance can

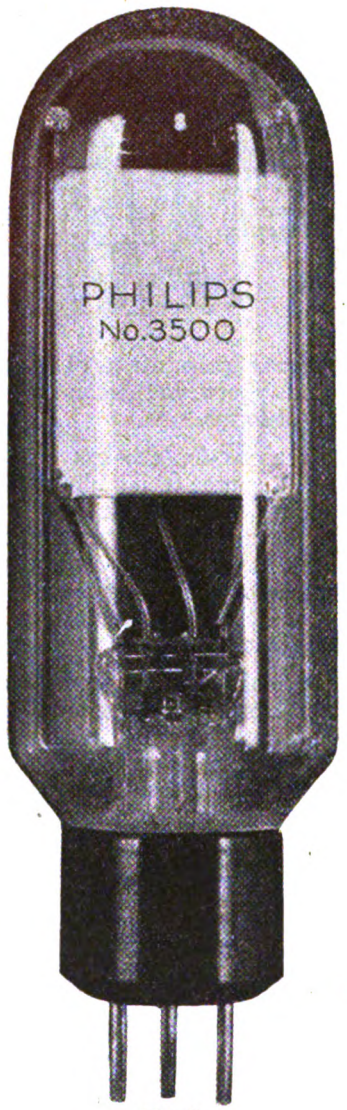


Fig. 7.
A Philips neon tube.

have a value of 1,000 ohms. The drop of potential across the terminals of the lamp is approximately 260 volts with a current of 20 milliamps.

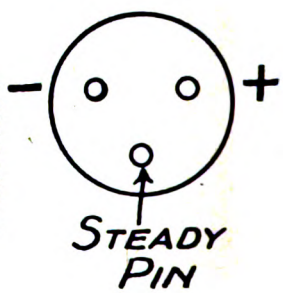
If the neon is wired in series with the plate circuit, as shown in Figure 4, the H.T. source must have a voltage equal to the sum of the voltage required for the power valve and the drop of potential across the neon lamp; for the valve type indicated, this will amount to 400 v.+260 v.= 660 volts. As now the internal resistance of the valve acts as a limiting resistance, no other resistance need be incorporated in the circuit.

With regard to the circuit arrangement shown in Figure 5, the necessary biassing voltage on the grid of the valve, not shown in diagram, and the resistance used in the neon circuit bear a definite relation to one another. Adjusting these to secure the best effect will produce a number of varying effects and offer endless scope for amusement, if one cares to follow it up.

When dealing with an actual television image it is as well not to adjust the voltage to get the background too dark. If this is done, black shadows will appear on the image, due to the plate of the neon tube not being evenly illuminated, *i.e.*, too low a voltage.

Although these three methods of coupling a neon to the last stage of an amplifier have been briefly mentioned

Fig. 8.
Neon tube base with three pins, one acting as a steadying pin and guide to prevent the tube being put in the holder with the connections reversed.



it must not be thought that they are the only methods that can be employed. They are purely typical circuits which so far have been found to give satisfactory results. There are several other methods, and, no doubt, as new types of neon tube are produced further circuits will be evolved. The subject is one which will repay careful investigation.

One other point. If trouble from oscillation is experienced when using a neon in conjunction with a wireless set, the trouble may be cured by screening the neon tube leads. For this purpose lead-covered wire, or the armoured cable used for motor-car lighting systems, can be used, the lead or armouring being earthed. It is not an unknown thing for a sensitive detector to pick up from unscreened neon leads and cause trouble.

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Synchronisation in Television

By T. S. ROBERTS

As has been frequently pointed out in the pages of this journal, synchronism is the most vital point in any television system. It has been known for some time that the Baird Company had perfected an automatic method of synchronising which does away with any need to transmit a special synchronising signal, either through a separate channel, or superimposed on the picture signal. For commercial reasons details of this device have hitherto been withheld.

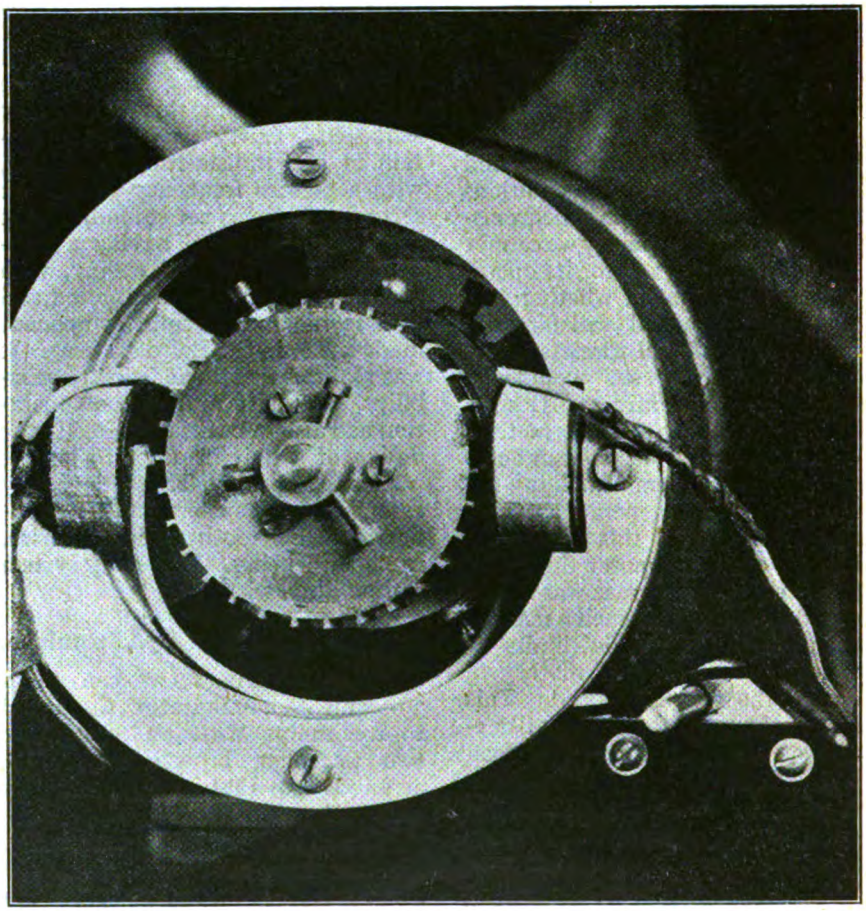
Now that the B.B.C. have commenced broadcasting television, however, arrangements are being made to place receivers on the market immediately, and we are thus enabled, for the first time, to give in the following article full details of the Baird automatic synchroniser. All who have seen a recent demonstration of the Baird system, or who see one during the Radio Exhibition, will be in a position to testify as to the remarkable efficiency of the device.

SYNCHRONISATION is a technical factor of paramount importance figuring largely in both talking pictures and television, and upon the attainment of which depended the entire success of both undertakings. Whilst synchronisation is necessary to both, the actual problem which had to be overcome in each instance differed radically. As is well known, synchronism in talking pictures implies the coincidence between sight and sound during reproduction, and should this circumstance not obtain, even though the shortcoming is perhaps an error of only a second or even less, the result is that the film is spoiled for the onlooker. Both recording methods at present in vogue, i.e., printing the photographed sound on a narrow track on the film itself, and using gramophone records, have brought with them in their train measures for meeting this requirement, which have proved generally satisfactory.

Synchronism Defined.

In television practice we cannot fail to produce synchronism as it is understood in the " talkie " industry, because any discrepancy existing between the propagation of image and sounds appertaining thereto is much too small to be of any account. With television the term refers to the speed of motors used, transmitting and receiving. Before a transmitted television picture can be viewed in a receiving televisor it is essential that its disc-rotating motor shall be accurately in step with that of the transmitting station, and the original fulfilment of this exaction constituted a vital step towards making television as a whole into a practicable commercial proposition.

Mr. Baird, early on, patiently investigated every known system of synchronising motors without discovering any which would comply with the peculiar conditions demanded by broadcast television. Eventually he abandoned the quest for an orthodox solution to the difficulty and evolved several methods of his own which he proceeded to adapt. His two outstanding devices are known as: (1) the relay system, and (2) the magnetic toothed-wheel system. These he rigorously tested one against the other until all doubt was removed from his mind as to which was the



A photograph of the magnetic toothed-wheel synchroniser, shown diagrammatically in Fig. 2. Circuit connections are given in Fig. 3.

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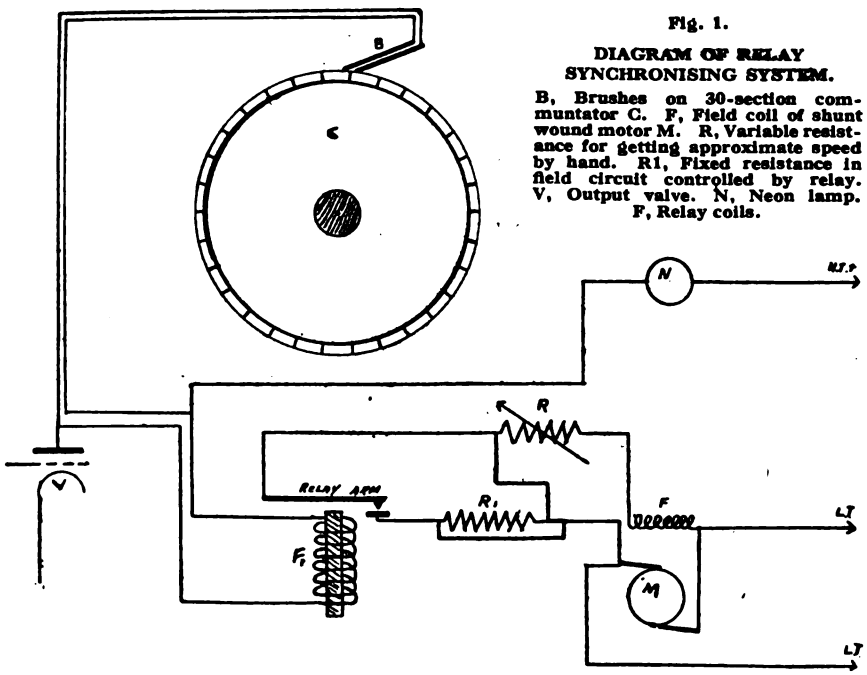


Fig. 1.

DIAGRAM OF RELAY SYNCHRONISING SYSTEM.

B, Brushes on 30-section commuutator C. F, Field coil of shunt wound motor M. R, Variable resistance for getting approximate speed by hand. R1, Fixed resistance in field circuit controlled by relay. V, Output valve. N, Neon lamp. F, Relay coils.

most efficacious. The decision giving preference to the latter as standard was reached some time ago, but owing to the patent situation, publication of the details has been withheld until now.

Conditions to be Met.

We must hark back somewhat and see what are the peculiar conditions attached to our television synchronising component. Obviously we cannot afford a separate signal for its operation, as it is doubtful whether this could be transmitted satisfactorily without an additional wireless transmitter, and even so, would be uneconomic in the extreme. Despite this, however, the original method adopted to secure synchronism actually did take the form of making the transmitting motor generate an alternating current, and this had to be fed to the receiving motor through a separate channel, where it was superimposed on the field in such a manner that within fairly wide limits it practically forced the motor to maintain the requisite speed. This method, though otherwise satisfactory, was abandoned for the reason mentioned, but were an A.C. supply of a uniform character available in every home throughout the country the principle could successfully be revived.

The speed at which our motor has to run is from 12 to 15 revolutions per second, and a variation of 1/30th of one revolution would be fatal to a good picture. To attain synchronism we are forced to utilise some function or integral part of our television signal. This is mainly variable, but luckily it possesses one unvarying characteristic, and this is its strip sequence. Thirty times per revolution of the transmitting motor (or, with a picture frequency of 12½ per second, 375 times per second) a strip of signal is radiated having a well-defined beginning and ending, with an appreciable intervening period, and that is the fundamental component made use of in the Baird systems. It was realised that, in addition to reliability, simplicity and ease of operation had also to be incorporated in the design of a unit in order to give it popular appeal. Thus the very ingenious relay system and its modification, the toothed-wheel device, came into being. The relay system will be dealt with first.

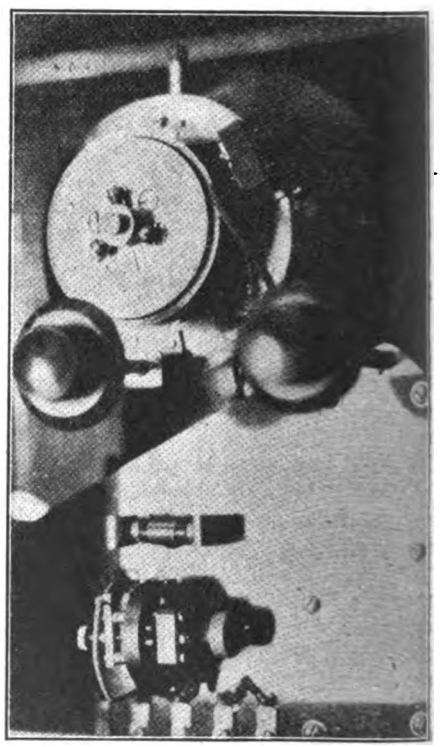
Details of Relay Synchroniser.

Consulting Fig. 1, we can see a 30-segment commutator *C* affixed to the motor shaft on which ride two phosphor bronze brushes *B*, arranged so that one is roughly 5 degrees ahead of the other. *F1* are the low-resistance windings of a relay, the armature of which controls a small fixed resistance, *R1* placed in series with the field rheostat *R* of the shunt-wound motor *M*.

H.T. is fed to the anode of the last valve of the receiving amplifier, firstly through the neon lamp and then alternately through the relay coils and the commutator. In consequence, 30 times per revolution, i.e., every time the brushes *B* are in the position indicated, the whole of signal current fluctuations pass through the relay. These fluctuations cause the armature to be attracted, which in turn short-circuits the fixed resistance *R1* and thus retards the motor speed. *R1* is only in series with *F*, the field windings, whilst the relay is open.

How it Operates.

To examine the operation in detail, the variable resistance *R* is used to bring *M* to the approximate speed of the transmitting disc. Provided both motors are running in step the relay does not operate, because whilst a strip of signal is causing current to flow in the anode circuit of *B*, the brushes *B* are short-circuiting the windings *F1*, and at the interval between no strips no signal current whatever flows in the anode circuit. Should *M* be running at a speed slightly in excess of the transmitter, then signal current is still flowing in the circuit, and as the brushes are staggered the relay ceases to be



Photograph of relay sychroniser, shown diagrammatically in Fig. 1. The commutator (above) and the relay (below) can clearly be seen.

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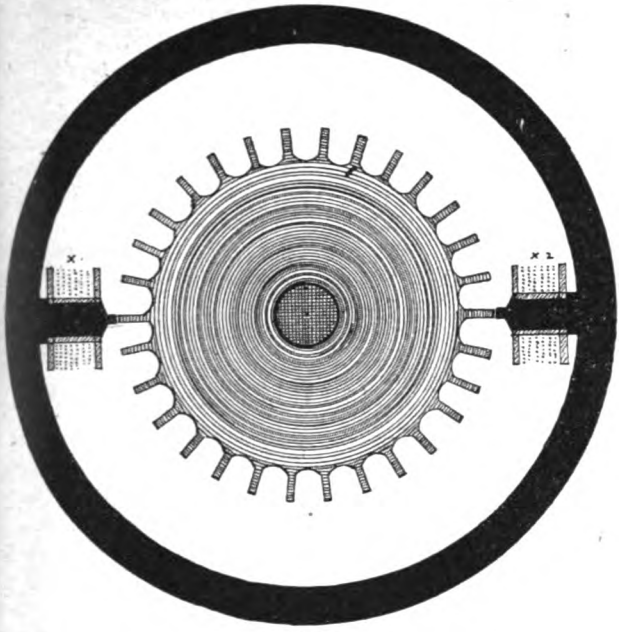

Fig. 2.

TOOTHED-WHEEL SYNCHRONISING.

The 30-toothed wheel revolves between the pole-pieces (heavy black) which are magnetised by the current which lights the neon passing through the windings X_1X_2.

shorted, the armature is pulled over, R_1 is cut out, and the resultant increase of current in F slows down M.

Should the speed of M be less than that of the transmitting motor, then the action of the relay, far from being able to improve matters, has, if anything, an adverse effect. In practice one usually adjusts R until the motor is tending to run a fraction faster than the correct speed, using the relay action as a brake only. The Fultograph synchronising system also operates with a similar setting.

There are several drawbacks to this method of synchronising. One is that the action of slowing up the motor so frequently and drastically imparts what is known as a hunt to the picture; it rises and falls an appreciable amount in a sort of rhythm in accordance with the correcting impulses given to the motor. The relay has to be accurately set up periodically, the contacts need frequent adjusting and cleaning, as do also the brushes, the wear of which is uneven due to their staggered arrangement. Nevertheless it provided the necessary control for all Mr. Baird's demonstrations, both wired and wireless, until the toothed-wheel device was thought of and proved to be more suited to the task. The relay method is also very suitable when a large and heavy disc has to be controlled.

The Magnetic Toothed-wheel Synchroniser.

The construction of the toothed-wheel unit is comparatively simple, and is as follows: Two electro-magnets are mounted on a circular metal frame-work at points 180° apart, and between their poles is situated a mild steel wheel having thirty evenly-spaced teeth projecting around its periphery, and these, as they revolve, pass before the magnet poles with a very minute clearance. The shape and facet area of poles and teeth are identical.

Referring to diagram, Fig. 2, X_1 and X_2 are the magnets, and the wheel is between them. Although not shown in the drawing, a rack-and-pinion arrangement is embodied which gives a 45° movement to the pole framework, for a reason which will be explained later on.

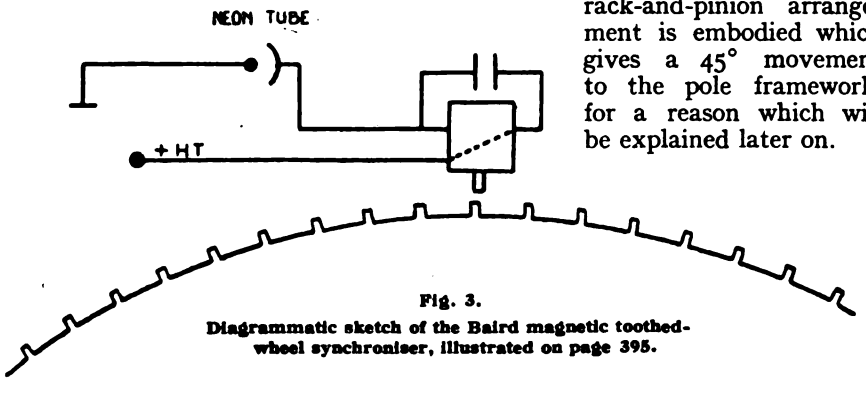

Fig. 3.

Diagrammatic sketch of the Baird magnetic toothed-wheel synchroniser, illustrated on page 395.

The action of this unit is not quite so simple, but will be described as comprehensively as possible. The received signal, after amplification, passes through the series-connected magnet coils, which themselves are in series with the neon in the anode circuit of the last valve in the amplifier. Every signal strip, by virtue of the various current values it contains, sets up a certain value of magnetic flux around the poles, and this at any and every instant is exerting itself on the two adjacent teeth of the wheel, at the periodicity of the transmitting motor.

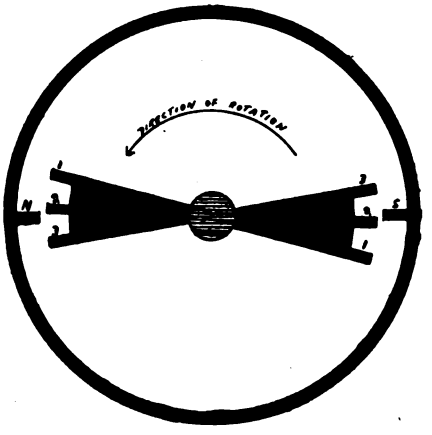

Fig. 4 (a).

In effect, this power is also more valuable as a brake to a receiving motor adjusted to run slightly faster than the transmitter, rather than as a means of urging it on should it be lagging behind. In Fig. 4 are shown four relative positions of poles and teeth covering one complete cycle of events. If a state of synchronism

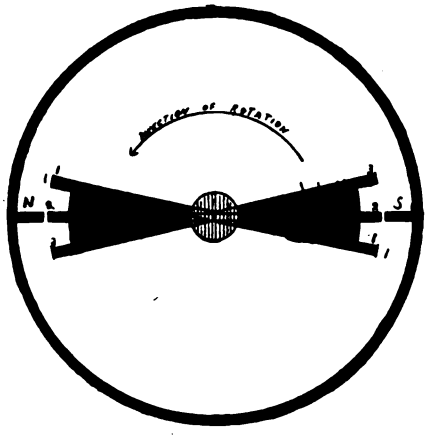

Fig. 4 (b).

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exists during this cycle we can analyse the influence applied by the magnets to the wheel as follows :—

In *A* the teeth 2, 2 are being pulled in the direction of rotation, in *B* the flux has no effect. In *C* they are pulled in the reverse direction, and in *D* there is also no effect, the pull being equally divided. It will be noticed that *A* and *C* to all intents and purposes cancel each other out. Now, suppose the receiving disc motor to be lagging by 6 degrees or less. In *A* there will be no effect because the poles will be demagnetised between strips ; in *B* the teeth 2, 2 will be strongly held by the strip signal flux, further slowing the motor and causing a rise in armature current. In *C* the effect of *B* is still present, though in a lesser degree, as poles 1, 1 are beginning to help, and in *D* the retarding influence of teeth 2, 2 is entirely gone.

In passing back to the *A* position, teeth 1, 1 help the armature which will then have its current slightly reduced. On the other hand, should the receiving motor be ahead of that of the transmitter, again by not more than 6 degrees, in *A* we find teeth

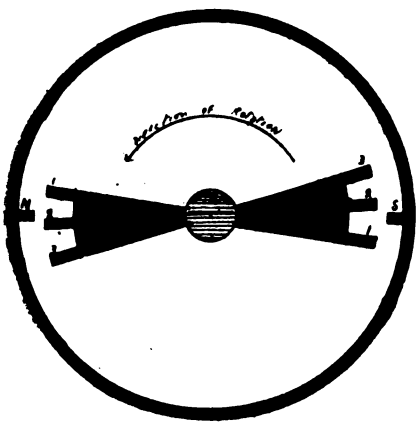

Fig. 4 (c).

2, 2 being pulled in the direction of rotation ; in *B* poles 2, 2 are strongly held, and the speed is consequently retarded ; in *C* there is no effect and in *D* also little or no effect.

In practice it is found necessary occasionally to correct the phase of the picture for images containing very marked relative light values, as these may give a disproportionately strong current impulse at one point along the strips, and that point, though having no deleterious effect, will determine the vertical position of the picture at synchronism. Moving the pole-pieces around by means of the control incorporated will counteract this tendency.

This system bids fair to become a recognised standard for television throughout the world, its advantages including simplicity, cheapness, ease of manipulation, little to cause

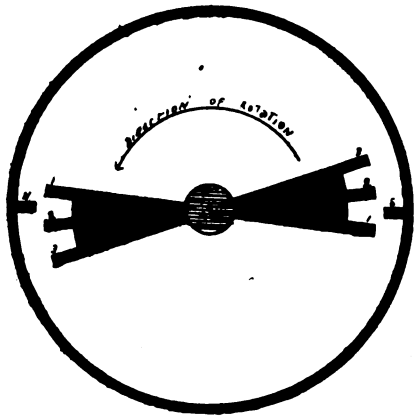

Fig. 4 (d).

trouble, and withal it holds the picture with great steadiness indefinitely during unchanging conditions. The hunt is so slight as to be negligible. In this connection, during a recent attempt at photographing a televised face from a televisor controlled by a toothed-wheel synchronising unit, it was found that throughout an exposure of 20–30 seconds the hunt only amounted to ·35 of an inch movement up and down from the mean at the sitter's end, which of course is barely noticeable to the human eye actually looking into the televisor.

ERRATA.

Please note the following corrections to article entitled "The Literature of Television," which appeared in our September issue :—

In the following items read 1929 for 1928 :—

Page 345, "Quantitative Analysis of Television."

Page 346, "Frequency Modulation."

Page 347, "Cathode Rays in Practical Television," in May TELEVISION.

On page 346, "Television, a paper read by Col. J. R. Yelf," read Vol. III for Vol. IV.

On page 346, "Alexanderson's Systems," read Vol. XX for Vol. XV.

J. H. O. H.

The Story of Electrical Communications.

(*Concluded from page* 392.)

are equipped with wireless must be licensed by the Postmaster General, and the Post Office carries out the wireless inspections on behalf of the Board of Trade. For this purpose, inspectors are stationed at the principal ports in this country, and over 3,000 ships are inspected annually. The new Convention lays down that in future a certificate must be issued every year to all ships fitted with wireless in accordance with the Convention, so that ships must be inspected at least once a year.

Watchkeeping.

Regulations regarding the wireless watches to be kept for safety purposes, that is for the SOS signal, are included in the Convention. Each passenger ship which is required to be fitted with wireless telegraphy shall, for safety purposes, carry a qualified operator, and if not fitted with an auto-alarm, shall, whilst at sea, keep watches by means of a qualified operator or a certified watcher, continuously if the ship is over 3,000 tons, or as determined by the Administration if under that tonnage. Similarly, cargo ships, if not fitted with an auto-alarm, shall keep continuous watch, if over 5,500 tons, or as determined by the Administration if under 3,000 tons. Between 3,000 and 5,500 tons, they must keep 8 hours watch a day. On ships fitted with an auto-alarm, this auto-alarm shall, whilst the ship is at sea, always be in operation when an operator or watcher is not on watch, the operator or watcher being on watch at the times laid down by the International Radiotelegraph Convention which came into force this year.

Hitherto watchers have proved to be of little practical use, and the Convention has recognised this by increasing the qualifications required. In future, a watcher must be able to adjust the receiver, read morse up to 16 code groups a minute, and be able to read the alarm, distress, safety and urgent signals when received through interference.

In conclusion, there can be no doubt that the advent of wireless has done more towards furthering the safety of life at sea than any other invention with the exception of the invention of the steam engine.

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The Distribution of Waves in Wireless Transmission

By R. L. SMITH-ROSE, D.Sc., Ph.D., A.M.I.E.E.

IN the earliest days of wireless history the great attraction to the few engineers and scientists working on this subject was to obtain telegraphic communication over the greatest possible distances. Communication was first established between the Isle of Wight and the mainland, then across the English Channel, and later, in 1901, the first simple Morse signals were transmitted across the Atlantic between England and Newfoundland.

While successful communication over greater distances rapidly followed, it was soon discovered that radio communication over anything more than one or two hundred miles was a very uncertain proposition, and that the strength of the received signals varied to a very large degree in a manner dependent upon the distance and time of day. Scientific research carried out in the interval has shown that much of this variability in wireless transmission is due to the fact that wireless waves are only propagated to great distances and round the curvature of the earth by travelling through the upper portions of the earth's atmosphere. The transmission of these "atmospheric" waves is subject to the influence of the sun's radiation and the earth's magnetic field in a manner which is quite uncontrollable from the earth's surface.

Smashing Through.

The methods of overcoming these difficulties have consisted in the development of increasingly powerful transmitters and more sensitive receivers, while of recent years the selection of different wave-length bands for use at certain times of the day has proved a very useful expedient. It has to be admitted that even to-day the successful use of commercial telegraphic communication relies upon the employment of equipment which will provide the minimum received energy during the worst periods of transmission, in order to maintain continuity of service. At more favourable times, the energy provided may be very much in excess of that required, but

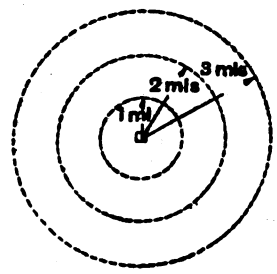

Fig. 1. Contour lines of equal signal intensity for waves radiated over a flat uniformly conducting surface.

this comparatively low efficiency cannot be avoided. Provided that the received energy does not fall below the minimum required at the worst periods, the variability of this energy is of little consequence in telegraphic communication.

Ground Waves Required for Broadcasting Service.

The inception of broadcasting, however, brought about somewhat different conditions which had to be met. For a satisfactory broadcasting service it is necessary to provide at the receiver a radiated field of constant strength at all times during the transmission of programmes. To establish a reliable service under such conditions it is necessary to rely upon those waves sent out from the transmitter which travel straight along the earth's surface. While such waves are not influenced by the conditions in the earth's atmosphere, they are greatly influenced by absorption by the portions of the earth's surface over which they travel. Consequently, after an interval of twenty years the effect of the earth's surface in modifying wireless wave transmission has been recently studied again in some detail. Since the requirements of sound broadcasting and television transmission are approximately similar in the above field, it will be interesting to review the factors affecting such overland transmission and to illustrate some of the typical results which have been obtained in actual experiments.

Absorption Effect of Earth's Surface.

In the case of the transmission of wireless waves over land a certain amount of absorption takes place in the ground itself. If the earth were made of silver or copper or some other equally good conducting material there would be little absorption of the wireless wave energy. Sea water is a good conductor, and over the sea wireless waves are propagated with very little loss of energy. It is for this reason that many wireless telegraph stations which communicate chiefly with ships are erected near the coast. The extent of the absorption in overland transmission depends upon the nature and dampness of the soil, on the trees and ground vegetation, and upon the existence of towns or mountainous areas. In England the effect of such absorption

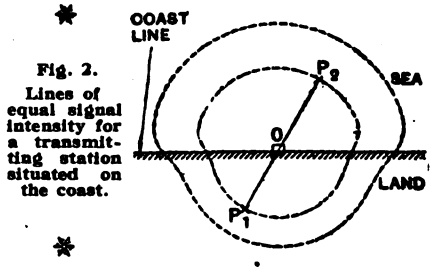

Fig. 2. Lines of equal signal intensity for a transmitting station situated on the coast.

is noticeable at distances of from 15 to 20 miles from the transmitter, even in the open country. Many transmitting stations are, however, situated at or near the centres of large towns, and in such cases an

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additional absorption effect is usually present, and this may become very serious within a few miles of the station. The resulting energy absorption which accompanies the transmission, particularly at the shorter wave-lengths, necessitates the use of a relatively large power to secure satisfactory reception at distances of only 20 to 100 miles.

Contours of Field Strength.

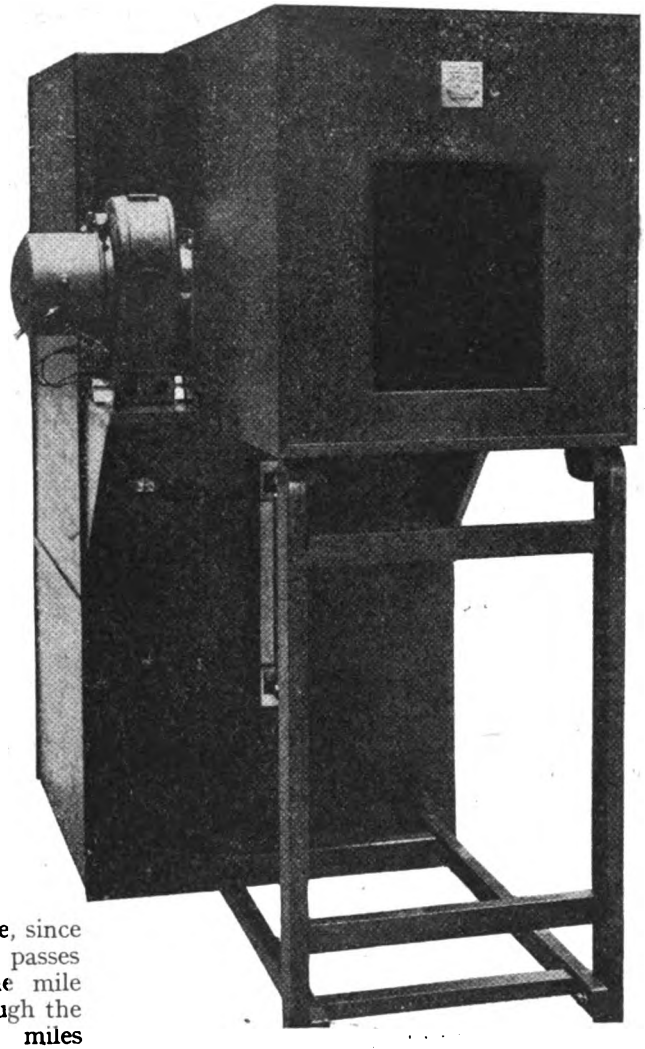
Let us suppose that, in the first instance, the earth's surface were a flat, perfect conductor. If a vertical transmitting aerial is located at any point on this surface, the waves will be radiated out horizontally to an equal extent in all directions. The expanding wave-fronts of the successive waves will, therefore, be concentric circles with their centres at the transmitting aerial as depicted in Fig. 1.

This case is analogous to the transmission of waves over the surface of a pool of water when this is disturbed by dropping a stone in it. If in Fig. 1 we imagine that these circles are the sections of small cylinders which have a fixed height in a direction perpendicular to the plane of the paper, a little consideration will show that the surface area of each of these cylinders is proportional to its radius. Therefore, since all the wave energy which passes through the cylinder of one mile radius ultimately passes through the succeeding surface of two miles radius, the energy concentration in the wave will be four times as great in the former as in the latter case. Further, since the field intensity of the wave is proportional to the square root of the energy, we see that this intensity decreases inversely as the distance from the transmitter.

If the conductivity of the earth is not perfect, but its surface is still flat and uniform, there will be a certain loss of energy due to the heating effects of the eddy currents set up in the earth by the waves travelling over it. This means that the energy of the waves will decrease with the distance from the transmitter at a rate greater than for a perfect conductor. The field intensity of the waves will thus decrease more quickly than the inverse distance from the transmitter.

Effect of Earth's Resistance.

General considerations show that the loss of energy becomes more rapid as the resistance of the earth's surface increases, although the effect is also dependent upon the dielectric constant of the earth. The energy loss also increases very rapidly with the frequency, with the result that, while on the longer waves of several thousand metres wave-length the loss may be small, it is very appreciable on the medium broadcasting band of wave-lengths, and it is still more so on the very short wave-lengths now being used for telegraphic and telephonic communication, and in some cases for sound broadcasting. In the latter case, indeed, the importance of the effect has already been felt in the difficulty of transmitting to quite moderate distances along the earth's surface, although very much greater distances may be covered by waves travelling via the upper regions of the atmosphere, and thus free from the heavy absorbing effects of the ground.



The Karolus television transmitter, as it appears to the sitter. At left, in rounded metal casing, is the arc lamp.

Whether the earth's surface be comprised of high- or low-resistance material, then, so long as its nature is uniform in all directions, the distribution of field intensity will be uniform as depicted in Fig. 1. That is to say, at any given distance from the transmitter the intensity of the signals picked up by a given receiver will be the same, whatever may be the direction in which the receiver is placed relative to the transmitter.

As a typical example of this arrangement, the case of a broadcasting station situated in fairly open country, such as Daventry, may be quoted. So long as the transmission is over moderately flat open country a given receiver should always produce the same results at the same distance from the transmitter. There is no question of "blind areas" of reception, and where the results are not uniform they are to be attributed to local absorption or screening.

Unequal Absorption.

Suppose, however, that the transmitter, instead of being situated in uniform country, is located on the coast line with the sea on one side and dry sandy soil on the other. Owing to the superior conductivity of the sea, the waves travelling in this direction will suffer less loss of energy than those travelling back overland. This means that at a given distance from the transmitter the intensity of the field will be greater over sea than over land, or, alternatively, that the same signal

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strength is obtained at a greater distance over sea than overland. The "contour" lines of uniform field strength will, therefore, no longer be

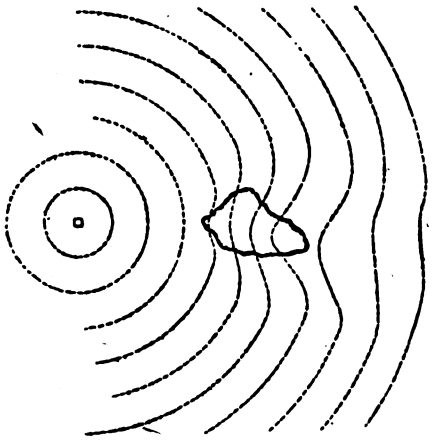

Fig. 3.
Effect of a badly conducting island on the shape of contour lines of equal signal intensity.

concentric circles as in Fig. 1, but will rather take the form shown in Fig. 2. The same signal strength will be experienced at the two points, P_1 and P_2, although the distance OP_2 is considerably greater than OP_1.

Next, suppose that the transmitting station is situated in fairly uniform country, but that at a short distance away a patch of very badly conducting ground exists, somewhat in the manner of an island in the middle of the sea. The wireless waves will begin to spread out uniformly, giving circular intensity contours, but when they reach the badly conducting area the rate of loss of energy will be suddenly increased, and the contour lines will be kinked in the manner shown in Fig. 3. It will be noticed that the spacing of the successive intensity curves is much closer over the badly conducting patch than over the remainder. When once this area has been passed, however, the kinks in the contour lines gradually smooth out and resume their circular form. It is thus illustrated how such an area of badly conducting ground becomes an area of bad reception; but it is also seen that the effects of such an area do not persist for a very great distance beyond it.

Experimental Investigations.

During the past few years several investigations have been carried out of the distribution of field strength around transmitting stations used for sound broadcasting. As the results of some of these investigations illustrate in a remarkably clear manner some of the points under discussion in the present article, it will be interesting to give a few examples.

The usual method of tackling the problem is to employ a portable signal-strength measuring apparatus which is transported to the various sites by motor-car. Working to a pre-arranged plan in which the points are selected with a view to showing up clearly the effects being investigated, observations are made of the field-strength due to the carrier wave of the broadcasting station at various distances up to about one hundred miles. The observations are carried out in the daylight hours in order to avoid difficulties due to the downcoming atmospheric waves, which are usually only of consequence at night-time on the wave-lengths concerned.

Field Strength Measurements.

In 1924 Messrs. Bown & Gillett published in the "Proceedings of the Institute of Radio Engineers" a description of measurements carried out in the neighbourhood of Washington and New York City. The results obtained around Washington showed that the field strength decreased with distance in a fairly uniform manner, although it was subject to some variation where the waves passed from land to water and also in passing over hills.

Wave Absorption in New York City.

In the case of New York the measurements were carried out on the transmission from a station situated near one end of Manhattan Island and employing a wave-length of 492 metres. As might be expected, the results obtained indicated that the distribution of field strength was very far from uniform; for this city, thickly covered with tall steel frame buildings, provides a large number of closed metallic loops as well as open aerials, which serve to extract energy from the waves in the course of their transmission. The results of the measurements are most easily understood from the diagram, reproduced in Fig. 4, from Bown and Gillett's paper, in which the field-strength contour lines have been superimposed upon an aerial photograph of New York City.

The large difference in attenuation of the waves in passing over open water and over the crowded city area is very well demonstrated by the relative spacing of the contour lines.

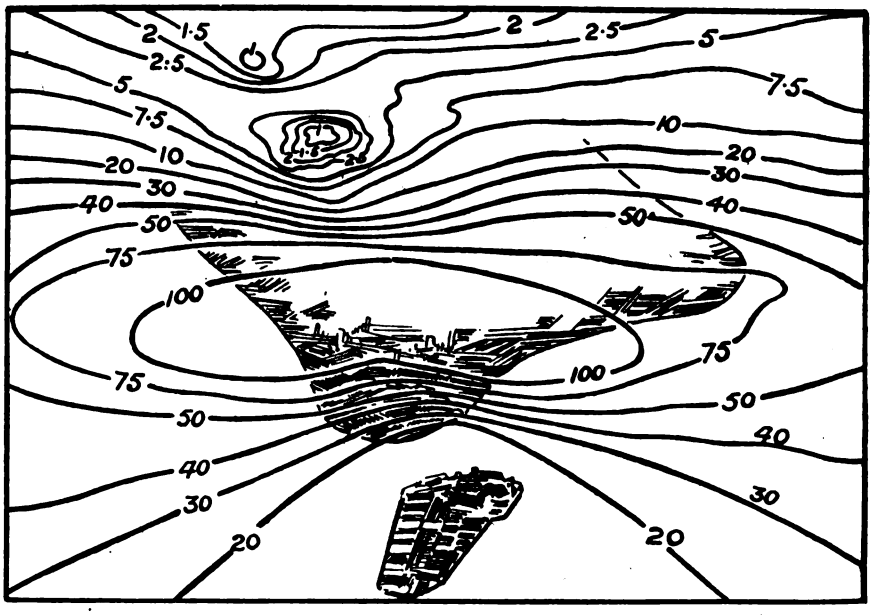

Fig. 4.
A sketch made from an aerial photograph of New York, upon which were superimposed the contour lines of field strength. The numerals indicate the field strength in millivolts per metre.

Towards the top of the photograph it is seen that the contour lines have closed in on themselves to surround

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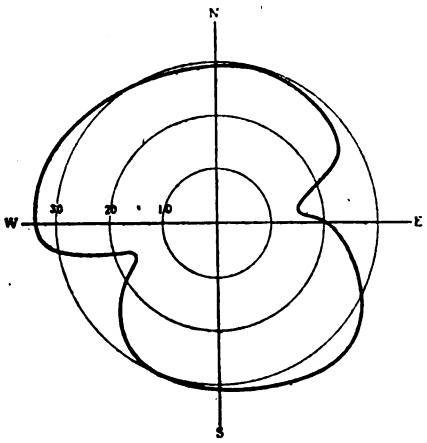

Fig. 5.

Polar curve of signal strength of 2LO at 10 km. from the transmitter (March 1927); intensities in millivolts per metre.

a small area within which the field strength was found to have a very low value. This area is located in Central Park, which is surrounded by the city on all sides, and it evidently forms a blind spot for broadcast reception. Although it is only six miles from the transmitting station, the field strength is no greater than it is at thirty miles or more out in the country in a more favourable direction. Since this blind spot is a closed area, it is observed that beyond it the field strength increases as a result of the feeding-in of energy from either side where the transmission conditions are much more favourable.

As stated by the authors of the paper from which these results are taken, New York presents a "horrible example" of the difficulties which are encountered in the transmission of wireless signals over city areas.

Field Strength Contours of 2LO.

During the past three or four years an extensive study of the field-strength distribution around the London broadcasting station, 2LO, has been carried out by Mr. R. H. Barfield. In these experiments attention was directed not so much to the absorption of the waves in passing over London itself as to a study of the subsequent progress of the waves in the outer suburbs and provinces where the majority of listeners reside. In order to obtain a polar curve of radiation for the 2LO transmitting aerial, observations were made with a portable intensity-measuring apparatus at suitable sites at a radius of about six miles from the transmitter. The polar curve obtained is shown in Fig. 5, from which it is seen that the distribution, instead of being uniform, is subject to two district minima in the approximate directions of east-north-east and west-south-west respectively. These minima or crevasses in the curves are ascribed to the directional characteristic of the transmitting aerial, and are probably due to the currents induced in the two metallic masts supporting the aerial.

Results of Survey.

The results of a complete survey of the field strength distribution of 2LO are summarised in the contour map of signal strength in Fig. 6, which is reproduced from a paper by Messrs. R. H. Barfield and G. H. Munro, published in the "Journal of the Institution of Electrical Engineers" in February, 1929. In this diagram the solid lines indicate the measured field strength, while the broken lines are circles described round the transmitter as centre. These circles are useful for comparing the signal strength in different directions at equal distances.

It is immediately evident from this map that the characteristic crevasses impressed upon the signal strength distribution near the transmitter persist at all distances up to the limits of the observations made. In addition to this, it is noteworthy that the contour lines are relatively compressed to the south of London as compared with their more open spacing to the north. This indicates that the absorbing effect of the ground on the wireless waves is much greater in southerly directions than in the directions north of London.

In a previous paper Mr. Barfield also pointed out that a comparison of the experimental results with theory showed that the absorption was greater than would be expected from the previously determined value of the earth's resistance. It was then suggested that both this fact and the directional feature of the contour lines could be explained as an effect due largely to the well-wooded nature of the English country-side.

To support this suggestion Mr. Barfield developed an experimental

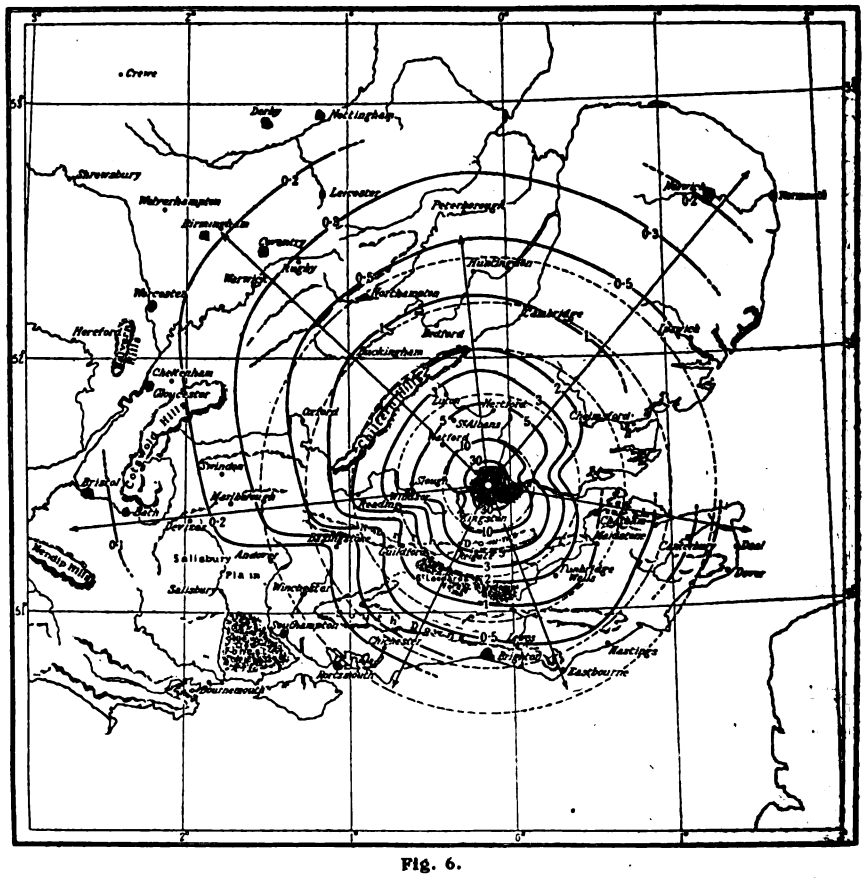

Fig. 6.

Radio contour map of 2LO; revised survey made in March 1927 (distances from 2LO shown by dotted circles at intervals of 20 km.); intensities in millivolts per metre.

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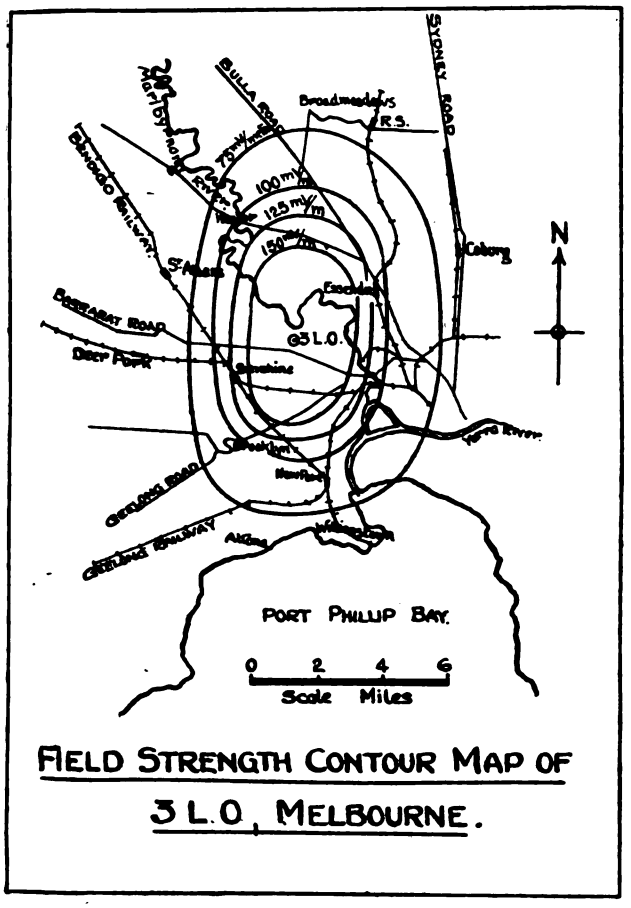

Fig. 7.

Field strength measurements made round 3LO, Melbourne, show a remarkable consistency in the all-round radiation qualities of the station.

method of measuring the effect on the field-strength produced by an individual tree, and from the results obtained the total energy-absorbing properties of a given tree-covered area could be calculated. The general conclusion arrived at was that masses of trees contribute very largely to the absorption of wireless waves on the broadcasting wave-lengths in the country, and that the difference of absorption in different directions is due to the distribution of trees. Thus the well-wooded areas to the south and south-west of London absorb the energy of the waves more rapidly than the comparatively treeless areas to the north and east, and so the signal intensity at any given distance may in one direction be little more than half that in a more favourable direction.

Experiments in Australia.

Somewhat similar measurements to those described above have been made on the transmissions from the broadcasting station 3LO, situated near Melbourne, Australia, by Mr. R. O. Cherry, of the University of Melbourne. This station operates on a wave-length of 371 metres, and measurements of the radiated field-strength were made at various places within a twenty-mile radius. The results are shown in the contour-map of Fig. 7, which is reproduced from one of Mr. Cherry's papers published by the Broadcasting Company of Australia. From this diagram it will be seen that the field-strength contour lines are of an oval shape, the signals being stronger in the north-south direction than in the east-west direction, a fact which is possibly due to a characteristic of the transmitting aerial itself. Apart from this, however, the contours are remarkably smooth, and are in great contrast to those shown for New York above. This smoothness of the contours is attributable to the good situation of the 3LO transmitter in open country and the absence of local absorption due to steel-frame buildings near it.

The examples given above lend support to the view that it is inefficient and undesirable to locate any transmitting stations providing either a sound or television broadcasting service in the centre of large towns, a practice which is rapidly becoming obsolete.

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FORTHCOMING LECTURES

The following lectures on Television, with slides and experiments, have been arranged to take place during October :—

Mr. J. DENTON, A.M.I.E.E., Jt. Hon. Sec. Television Society, has the following engagements :—

Oct. 10th.—The Magnet Telephone Society, Coventry, at 8 p.m.

Oct. 11th.—The Sevenoaks Society, Sevenoaks, at 8.15 p.m.

Oct. 23rd.—The Muswell Hill Radio Society, Muswell Hill, at 8 p.m.

Mr. A. DINSDALE, A.M.I.R.E., Editor of TELEVISION, has the following engagements :—

Oct. 14th.—Troon, Ayrshire.

Oct. 15th.—Y.M.C.A., Glasgow.

Oct. 28th.—Taunton and District Radio Society, Taunton, at 7.30 p.m.

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DIELECTRICS

By W. F. F. SHEARCROFT, B.Sc., A.I.C.
Fellow of the Television Society

IN designing circuits or constructing sets we are mainly concerned with getting the electric current to flow satisfactorily through some conductor. In fact, conduction of electricity is most prominent in all that deals with electrical matters. We are apt to forget the great importance of the subject of insulation.

Actually, of course, insulation is as important as conduction. Conduction, as we understand it, could not take place at all without suitable insulation. The current which flows along a copper wire is as much determined by the surrounding layer of insulating air as it is by the metal conductor. It is an interesting speculation to imagine the science of electricity in a world possessing a conducting atmosphere!

Much of the success of any electrical installation depends on the efficiency of the insulation. The problem becomes very serious when we are dealing with high-tension distribution, when currents with pressures of many thousands of volts are transmitted through wires. These wires need some support, and every support must be an efficient insulator.

Porcelain Supreme.

In this connection porcelain has no rival, and is manufactured with great care. Usually English ball-clay and china clay are mixed with a finely-ground potash feldspar and flint. After being filter-pressed, the mixture is set aside to age, which eliminates air bubbles, after which it is thoroughly mixed in a pug mill, and moulded into the desired shapes.

The shaped articles are then oven dried, trimmed and glazed, and the final firing performed in kilns, the temperature of which can be regulated. This temperature regulation controls the porosity and the brittleness of the finished product.

The insulator is then subjected to a number of tests, including a flash-over test, under pressures of anything up to 300,000 volts.

Crude rubber is another very good insulating material; but, unfortunately, in the crude state it is not of much value, as its properties alter with age. Crude rubber is a colloidal material the chemical nature of which is rather doubtful. The formula $(C_5H_8)_8$ has been given to it, but this is probably only an approximation.

Discovery of Vulcanisation.

For commercial use rubber was not of much value until the discovery of the process which we now call vulcanisation. This was first accidentally discovered by William Goodyear in 1839, after many years of experimenting. It is related that he dropped a mixture of rubber and sulphur on a hot stove, and fortunately examined the residue. It is a strange commentary, when we think of the modern use of vulcanised rubber, to recall that Goodyear spent more than one period in prison for debt as a result of his enthusiasm, which did not secure the backing of financiers.

The process of vulcanisation of rubber is a chemical one, and consists of certain reactions which take place between the caoutchouc molecule and sulphur. The simplest method is the mechanical mixture of the purified crude product with sulphur. To the crude rubber there is usually added about one-tenth of its weight of sulphur. The mixture is warmed to soften it, and then moulded into whatever shape is required, or rolled out into sheets. Vulcanisation takes place when the moulded product is further heated to between 135° to 150° C. This is done in closed iron vessels by means of steam or hot air.

A so-called *cold cure* process is in use in which the rubber article is dipped in a solution of sulphur chloride dissolved in carbon disulphide, and then heated to about 40° C. in leaden chambers, or it may be suspended in the chamber and the vapour of sulphur chloride allowed to pass over it.

A modern process which has met with success is to expose the rubber first to the action of sulphur dioxide gas for ten minutes, and then to hydrogen sulphide for thirty minutes. These two gases, when mixed, react with the production of sulphur. Produced within the body of the rubber into which the gases diffuse, the sulphur is in an active state which brings about vulcanisation in the cold.

Modern research has considerably increased the rate at which vulcanising takes place by the addition to the mixture of various accelerators. Litharge was used for this purpose, but is now being replaced by a number of more or less complex organic compounds, mostly tar derivatives.

The product is too well known to need description. Vulcanised rubber varies in its nature according to the quantity of combined sulphur it contains, and analyses vary. The rubber itself may vary from 12 to 60 per cent., while the sulphur varies from 1 to 2 per cent., mineral matter may be 25 to 70 per cent.

Constitution of Ebonite.

If the proportion of sulphur be greatly increased then the product obtained is hard, moderately brittle, and will take a very high polish. This is the well-known *ebonite*, used so widely for non-conducting panels in wireless outfits. Commonly it is made by mixing purified Borneo rubber with about 40 per cent. of its weight of sulphur. After shaping, the mixture is heated for several hours at a temperature of 135° to 150° C.

Shellac is another useful insulating material. It is a resinous material produced by the female of an insect which infests various trees growing mainly in the East Indies. The resin forms an incrustation on the twigs,

(*Continued on page* 408.)

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"SELLING AMERICA TO THE WORLD!"

Can the U.S. "Corner" World-Entertainment? Where Does Britain Stand?

By SHAW DESMOND.

America means to corner the Entertainment of the World
Giant "Mergers" are planning the Conquest of Europe
Asia and Africa to follow
Television to be the Weapon

WITHIN five years from now radio-England will be face to face with America upon a battlefield which will be for her either her Waterloo or her victory.

Upon the result of this battle, you who read these lines may find yourself either flung out on to the street from your employment or may see your salary raised to a figure beyond your present dreams.

Upon it will hang the destinies of at least the three millions of people who by that time will be engaged in the radio, cinema, "talkie" and kindred industries, including the manufacturing.

Every theatre and hall in Great Britain will depend upon the result of that battle for its final control. There will scarcely be a dancer, an actor, an actress, or a singer who will not find his material destiny altered by the final verdict of that battlefield.

And I am certainly not going too far in saying that upon that verdict may ultimately hang the whole financial control of the earth.

How far this language is exaggerated or, as I contend, strictly within the bounds of moderation, you must decide by what follows.

A Gargantuan Struggle.

There is going on in America to-day a gargantaun struggle between two vast groups of interests for (1) the control of American entertainment, (2) the subsequent control of the entertainment of the British Empire, and (3) the control of Asia's yellow myriads and of the black hordes of Africa.

That struggle is being fought out between the American Telegraph and Telephone Company, for whom I recently broadcast from their palatial offices in Lower Broadway, and the Radio Corporation of America.

For three to six months you will hear the rumblings of this underground struggle come over the cables from New York, but neither you nor I will know of the result until the entertainment barons have settled the matter between themselves.

SOME months ago we were the first of our contemporaries to report the presence in this country of Mr. M. H. Aylesworth, President of the National Broadcasting Company of America. He came over to study our broadcasting methods, and as a result of his visit he announced that he hoped to organise a freer interchange of programmes between this country and America. As a result British listeners now find themselves occasionally treated to programmes paid for by American advertisers, whose object is indirect advertising.

Each of the combatants is calling up vast reserves of men and of money for what is a sort of local Armageddon, in preparation for that real ultimate Armageddon when together they will stand side by side against what I regard as one of the worst organised countries on earth—Great Britain.

Another Gigantic Merger.

I believe that the ultimate result of their mutual battle will be another gigantic "merger," and that then they will immediately set their united battle-front in order for England.

Woe to this country if by the time these two giants are ready she has not set her radio and wireless house in order!

The weapon which the Americans mean to use against British entertainment is the weapon of television. That weapon could and should first have been grasped by Great Britain, for television is the invention of a Scotsman, Mr. John L. Baird. I have only met Mr. Baird upon one occasion and so hold no special brief for him. But some day I hope to tell the world, as our American cousins have it, of the shabby, unimaginative treatment to which this gifted man has been subjected by this country.

But this weapon is now firmly in the hands of the two pseudo-combatants, who, taking time by the forelock, have been thinking exactly ten years ahead of England in the domain of "seeing at a distance."

They had reached the conclusion, to my personal knowledge, so long ago as 1927, that within a few years television would be a regular commercial proposition, that the television screen would be as common as "wireless" in the homes of England and America, and that it was the dominant factor in all future world entertainment.

Nearly two years after that, the British Broadcasting Corporation were timidly offering three quarter hours per week to the Baird Television people!

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Already their teeth have been sharpened by preliminary mergers.

Paramount have arranged a merger with Warner Brothers, and five representatives of Paramount have already become directors of the Columbia Broadcasting Company. Other powerful mergers are maturing as fast as the financial controls can be got to work. "Tie ups," the modern term for amalgamations, are taking place at the rate of one a day. Soon the Americans will be ready for the first offensive with shock-tactics.

Preparations.

I must say here that the new offensive is already being planned exactly upon the lines of a Western Front offensive. The trenches have been marked out; the supply lines have been skeletonised; and the officers in command are beginning to be appointed.

There will be neither let up nor easement once the first shell is fired until the "cease fire" sounds one year or ten years later.

The first "scouting" before the shock-offensive is seen in the instalment in the homes of Britain of large and increasing numbers of their "systems," i.e. the systems of the American Telegraph and Telephone Company and the Radio Corporation of America. Within two years from now I think we shall see at least five thousand installations a year, perhaps ten thousand.

Every Listener Affected.

Now I want the intelligent reader, who should always bear in mind that these tactics concern himself, his wife and his family intimately, if he be connected with "wireless," and less directly if he be outside "wireless," to follow step by step my forecast as to the future developments of the new campaign.

When the shimozzle between the two rival groups is over and one side or the other has secured some slight advantage over its rival we shall see an entirely new series of "mergers" launched.

We shall see an attempt made, one that has been on the carpet for three years or so, to link up the *transmission* with the *publishing* and the *manufacturing* sides of radio.

Already one of the groups has bought out one of the leading publishers of light music and is now in a position to handle the television end at any moment.

The great film-producing firms will be linking up with the publishing and the part-manufacturing firms. That is the next step.

Then will follow wholesale purchases of theatres and halls, as in the case of the Radio Corporation which has just bought the important Keith Albee circuit and, as I believe, one of the largest Middle West circuits of theatres and music halls, many of which I have personally visited in Chicago and elsewhere.

Now comes that final step, which should really have been taken by this country, and not by America. That is the placing on the market of the *stereopticon* which is owned by the Radio Corporation of America.

The very latest picture of one of the world's most famous comedians. Sir Harry Lauder has made countless tours and faced thousands of people, but on September 1st he appeared for his greatest audience and at the same time made his American radio debut over the system of the National Broadcasting Company. He was featured over a coast-to-coast network of thirty-six associated N.B.C. stations and three stations in Canada. His appearance was made in Winnipeg, Canada.

The stereopticon is a new invention consisting of a stereoscopic film, with all the characters standing out as in life on the screen, the coming of which, I think I can claim without immodesty, I was the first to predict in this country—many years ago. I was laughed at for my pains!

This stereopticon has already been demonstrated upon a vast opaque glass screen 70 feet wide—the size of the proscenium of a big theatre.

At present I think I am right in saying that demonstration in colour is not yet possible. *But it is coming.*

We shall see before five years are out men and women on the screen *in their natural colours*, as in life.

All these various interests and inventions are to be securely linked up into an impenetrable front, and when this has been done they are to be launched at Great Britain.

Behind them there will be the thousands of millions (they no longer calculate their mergers in mere hundreds of millions) of American dollars to which we are growing accustomed.

Rival interests here will either be "bought out or smashed out" as an American put it to me in New York some time ago, and we are going to see some of the old Standard Oil methods now applied to radio.

I have recently seen details of the penetration by America of the following countries:—

Latin-America.	Central America.
Canada.	The Middle States
Australia.	of Europe.
Russia.	Germany.
France.	Switzerland.
Italy.	Czecho-
Spain.	Slovakia.

The actual facts of that penetration make illuminating, if staggering, reading. If those facts could be broadcast by the B.B.C. to the inhabitants of this country, they would cause a minor revolution.

Well, what has Great Britain to set up against all this? What are her chances in the struggle now opening? Has she any chance at all?

Humanly speaking, not a dog's chance, unless she at once sets her television house in order.

Britain's Only Chance.

Her only chance is to take the long national-international view of television and at once make arrangements through the Postmaster-General to make television an integral portion of all wireless entertainment. Not even the present offer five of half-hours a week, though they are better than nothing, will help in what is a matter of life and death to commercial Britain.

That is the first step.

(*Continued on page* 408.)

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Sydney A. Moseley

ON

The Future of Television

IN the last issue of TELEVISION I told readers not to be unduly depressed by the statements made in the public press that negotiations between the B.B.C. and the Baird Company had been broken off.

Pessimists and the unkind were ready to say "I told you so," but those who have been unswerving in their faith knew that sooner or later television must be broadcast by the only available means in England.

At any rate, the optimism expressed was justified, for the B.B.C. have now arranged with the Baird Company to transmit for half an hour daily, with the exception of Saturdays and Sundays.

This is not so bad as a start.

Only those of us who have fought the battle for television all along think that *instead of doing the thing piecemeal, television should have had its proper place in the programme right away*. That is only natural.

Make a Start.

At the same time it is far better to make a start, and I hold that the offer of the B.B.C. is sufficient *to demonstrate beyond all doubt the place that television should occupy in daily transmissions.*

For, remember, this concession to the Baird Company has only been made *after repeated public tests* have been given, and when a jury of Members of Parliament pronounced in favour of it.

Also, let it not be forgotten that three Postmaster-Generals and ex-Postmaster-Generals have witnessed television at the Baird studios. They were the present Postmaster-General, Mr. Lees-Smith, the late Postmaster-General, Sir William Mitchell-Thompson, and Sir Herbert Samuel. All this is by the way, and I merely mention the matter because it is necessary to remind those unyielding critics who talk about the present facilities as being "very generous," of the true facts of the situation.

At any rate, scientific history has now begun in earnest, and television is being broadcast from the British Broadcasting Company's studios.

What of the future? While this battle in England was being fought foreign countries have been forging ahead. We have seen what has been happening in Germany, and from the Editor's report in another part of this journal, readers will realise how necessary and urgent it was to bring things to fruition in England.

Readers will remember that I talked of "tele-cinema" in recent articles. Germany in particular sees in "tele-cinema" or "tele-talkies" the stepping-stone to television proper.

My own view is that television itself is far more interesting, for here one *sees the real living image of the person or scenes transmitted*, whereas in "tele-cinema" one sees the *film* of a person or scene.

The First Film.

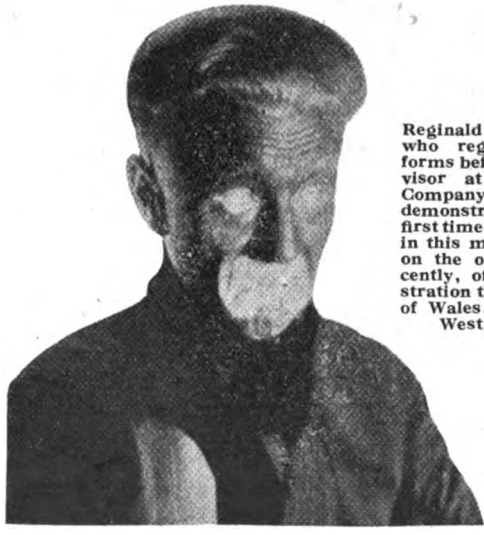
I gather that the first film to be televised by the Baird Company may be that of Mr. George Robey in his inimitable guise of a much-married woman!

I have seen and heard this transmission and found it most amusing, and a friend of mine who was present at a London club tells me that the Prince of Wales was particularly interested, and laughed loudly when this transmission was put over. He was also amused at the patter and facial expressions of Mr. R. Shaw of the Baird Company, who blacked his face and was clearly seen as a minstrel!

Granted all this.

For myself I look forward to a leading personage *being televised direct* and not second-hand from a film.

I would like, myself, to see the Prince of Wales, or I would even aim as high as obtaining the first public talk since his illness by the King!



Reginald S. Shaw, who regularly performs before the televisor at the Baird Company's television demonstrations. The first time he appeared in this make-up was on the occasion, recently, of a demonstration to the Prince of Wales, given in a West End Club.

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I have received several letters of congratulation from readers who have been following my campaign in this journal and elsewhere for the recognition of television in England. What has been achieved up to now is no doubt highly satisfactory, but we must not be blind to the fact that our foreign competitors are still very active and are making incessant efforts to undermine the lead and prestige of the British inventor.

Foreign Blandishments.

I gather that the blandishments of certain foreign emissaries have not passed altogether unnoticed either at Savoy Hill or at the Post Office. It would be inconceivable, in view of Mr. Baird's great victory, that any newcomer should be allowed to steal a march on the indefatigable Scot.

While one admits that science has no boundaries and that the best developments in television should be adopted by this country, the very least that can be expected in these days of depressed trade is to encourage British inventions and British production whenever the chance offers itself.

There can be no excuse at all for not giving every encouragement and every facility to the British Company now that it has proved itself.

Readers must not imagine that with the introduction of this half-hourly transmission we have achieved all that we have set out for.

Security of Tenure.

It would be farcical if, as a result of this early experimental transmission, full facilities were not given to the Baird Company after a short time.

Listeners all over the country will want sets, and obviously British manufacturers will be nervous of going into full production until they are assured that British official support will be given to the British Company and the British inventor, and that no back-door influence will permit a foreign invasion at the eleventh hour.

Nobody can gainsay that this country has given the world the lead in television and it has maintained that lead abroad.

Now that Baird television is to be broadcast by the B.B.C. the development of the new science must be encouraged in every possible way.

Every reader of TELEVISION will, I am sure, applaud this sentiment.

Dielectrics.

(*Concluded from page* 404.)

which are picked at regular intervals. This product, known as *lac*, is then washed with warm water to remove certain dye materials and the residue is the *shellac* of commerce.

Mica is another well-known insulator. Mica is properly the name of a group of rock-forming minerals of which *muscovite* is the best known. The micas are characterised by the ease with which they cleave into thin flakes. They are complex and variable in composition. Muscovite is usually given the formula $H_2 K Al_3(SiO_4)_3$, but this, is probably only approximate. The flexible sheets are largely used in the construction of dynamo armatures.

Gutta-percha, another useful insulating material, is acquired by evaporating the milky juices obtained from certain trees growing mainly in the Malay Peninsula. Gutta-percha consists of a hydrocarbon—pure gutta—which is closely allied to caoutchouc, together with certain resinous substances. The proportion of these constituents varies with the nature of the trees from which it is derived. It can also be vulcanised.

The element sulphur and the hydrocarbon paraffin, in the solid wax form, are also useful insulators for use on a small scale. There are also a number of liquids which are used as dielectrics.

The *volume resistivity* of a number of common non-conducting materials is given in the following table :—

Substance.	Millions of megohms per centimetre cube.
Mica	84
Gutta-percha ..	450
Flint glass ..	1,020
Vulcanised rubber	1,630
Shellac	9,000
India-rubber ..	10,000
Ebonite	28,000
Paraffin	34,000

Increase of temperature is usually accompanied by a decrease of resistivity. A rise of 25° C. reduces the resistivity of gutta-percha to one-twentieth of its original value. There is also a time effect, the resistance decreasing with the time to which the dielectric is submitted to electrical strain.

"Selling America to World"

(*Concluded from page* 406.)

The next step is for the trade interests, whether they be film producers, radio manufacturers, music publishers, makers of gramophone records, or what not, and, of course, including all the technical industries and processes which form an intrinsic part of modern wireless entertainment, to get together.

After they have thrashed out, and quickly, the values of their respective interests, let them merge, and merge, and go on merging. In merging lies salvation. In separation damnation.

A Solution.

Turn Great Britain into one gigantic homogeneous radio entity with television for its backbone. Let the Government, if necessary, at once subsidise television part manufacturers and give encouragement to the British pioneers of television for the placing of television screens in the homes of England. (By that they will, incidentally, by degrees solve their unemployment problem, wipe out the dole, and make the Britisher a self-respecting individual once more.)

But with this must go a wiping out of all monopolies.

Free and full competition within the country, unflinching and minutely organised opposition to the attack coming from the *outside*. That should be the policy.

But in all this, television must necessarily be the beginning and the end. It is the chief, almost the only weapon of the great American mergers in the fight that is now opening. It must also be Britain's chief weapon of defence.

I have ventured one forecast. Now I will venture another.

Another Forecast.

If Great Britain does not at once set her house in order and nationally organise against the American invasion, we shall see, without possibility of re-conquest, all the wireless entertainment *and wireless education* of the British Empire pass into American hands.

Already I know of plans for a flank attack upon certain of the British radio interests via France and Holland. That attack will be enormously difficult to meet.

What will England do ?

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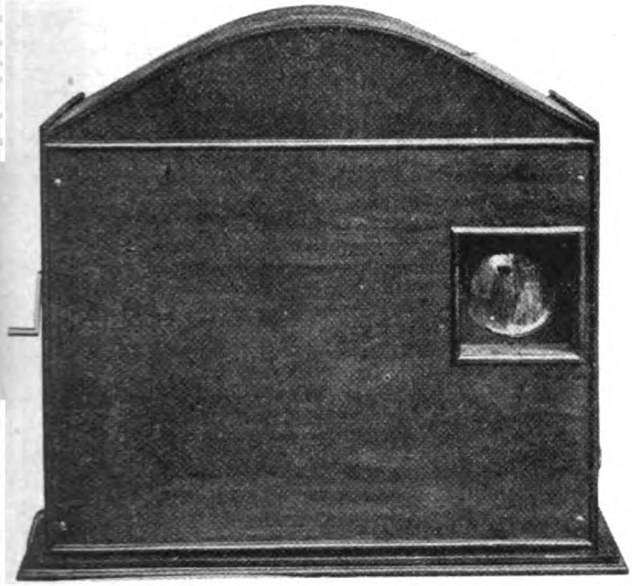
THE CONSTRUCTION OF EXPERIMENTAL TELEVISION APPARATUS

Part V

By A. A. WATERS

Working in collaboration with Captain R. Wilson, a member of the Council of the Television Society, Mr. Waters has been engaged on television experiments for some time. Photographs of Captain Wilson's transmitting apparatus, as it is to-day, appeared in our last issue. To illustrate the following article we reproduce two views of the receiver, details of which are given below.



Front view of Captain Wilson's receiver.

EARLIER articles in this series have described the construction of the apparatus necessary for the transmission and reception of simple shadowgraphs.

In this article I am going to give details regarding a receiver which we built for the reception of lantern-slide pictures.

Last month's issue of TELEVISION included photographs of the transmitter and pilot receiver used by Captain Wilson and myself in our experiments along these lines—instruments which represent the outcome of many months of research.

Those of my readers who have paid me the compliment of following these articles will readily appreciate the fact that in all experimental work apparatus has to be altered constantly—often it requires to be entirely rebuilt—in the endeavour to attain the result aimed at. In making a general survey of the work which has been accomplished to date, we may regard with some satisfaction the collection of apparatus which we have accumulated as a result of our efforts to improve our knowledge by practical experience. Failures have often occurred, it is true, but much valuable information has been gained from every experiment we have carried out.

The televisor I am about to describe was linked to the transmitter by a land-line about 300 yards in length. It is necessary to lay this line carefully if loss of the higher frequencies is to be cut down to a minimum, and the two leads should be well separated. Stray capacities should be avoided as much as possible.

The construction of the televisor can be clearly seen in the accompanying photographs. The woodwork is a fairly straightforward job, and does not call for a great degree of skill. The material used for the sides and base is $\frac{3}{8}$-inch 5-plywood, and both back and front are arranged to be detachable. Screws at the corners hold them in position. The only portion which may cause trouble to the constructor is the curved top. The requisite bending is carried out in the following way.

Bending Plywood.

First, cut the piece of plywood to the correct size and thoroughly soak it in water. After it has been immersed in the water for an hour or longer take it out and apply heat to one side. When it begins to steam commence to bend the wood away from the heat until a curve having a smaller radius than that of the curve aimed at is reached. This process will probably have to be repeated two or three times. When a curve of the desired radius is finally attained the wood must be

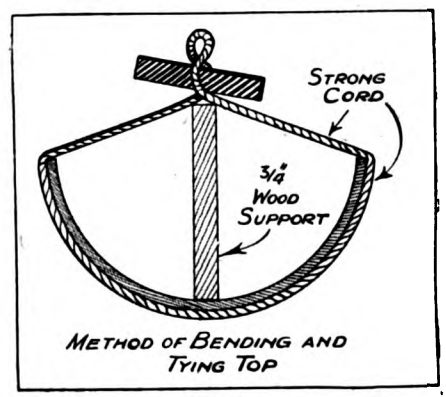


Fig. 1.

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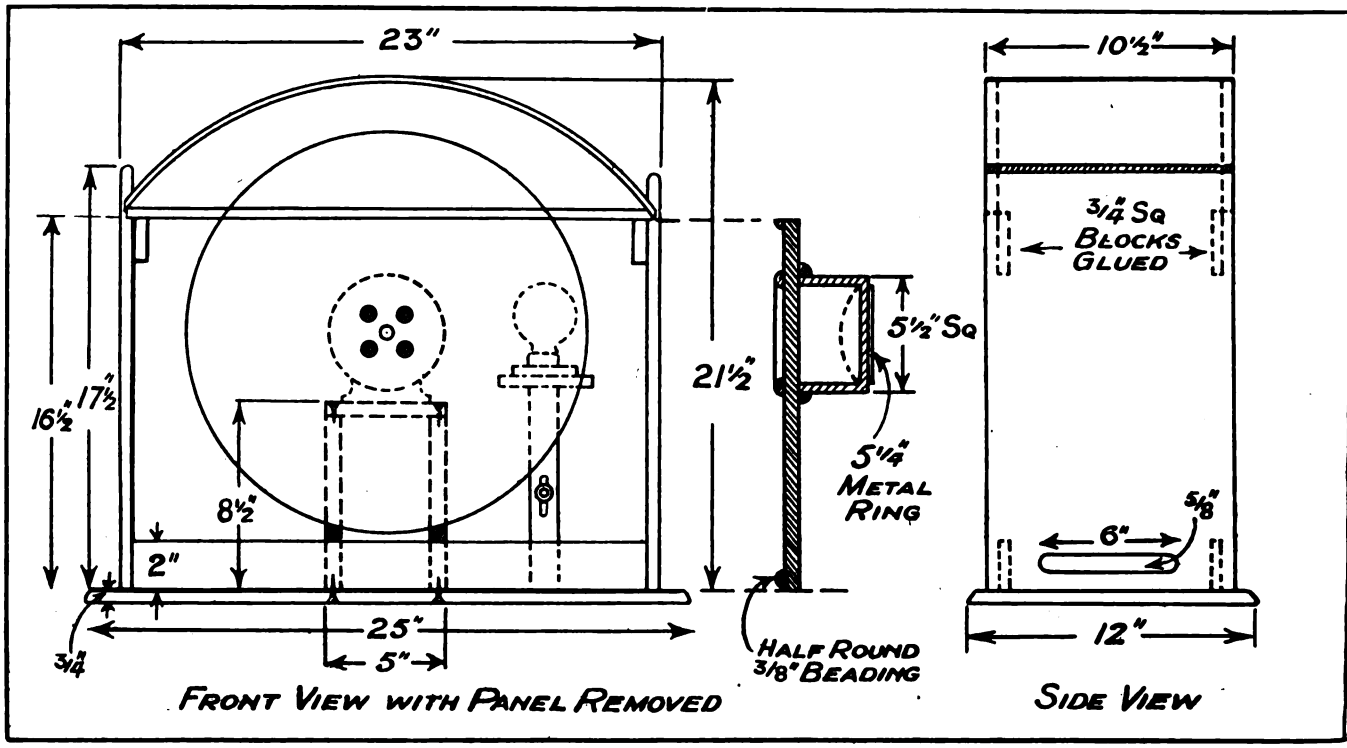


Fig. 2.—Side and end elevations of television receiver.

tied in position and left to dry. The tying is accomplished with the aid of the tourniquet method of straining, two strong pieces of rope being used.

I have included a small diagram which illustrates this method plainly (Fig. 1).

Such a curved top as I have just described is well worth the effort necessary to make it, as it takes away that "square box-like" appearance which would otherwise render the cabinet unsuitable for use in a well-appointed room. In Fig. 2 are given the dimensions of the cabinet, which is designed to house a 20-inch diameter scanning disc. Inside the cabinet should be painted black; the choice of the outside finish is left to the taste of the constructor—our particular job was treated with mahogany stain, and looked very well.

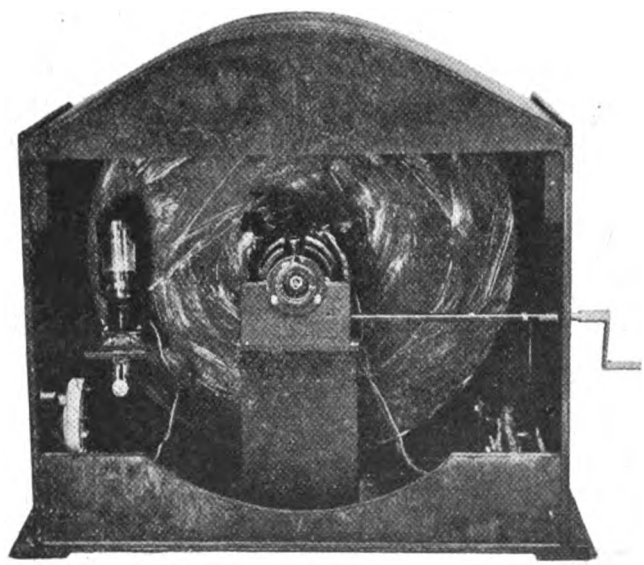
The platform on which the motor is mounted is made from deal board, ¾-inch thick, and is screwed together with No. 8 wood screws 1½ inches long. This makes a strong job, and ensures freedom from vibration.

The details of the neon tube holder were given in my first article, and as the same holder is used I have included a diagram of the finished article only.

The type of motor required for driving the disc will depend upon the supply which the intending constructor has available. In our case a G.E.C. 1/40th h.p. Universal motor was used. The speed was varied by means of a 1,000-ohm slider-type resistance, such as is supplied by Isenthal's or the Zenith Manufacturing Company. This resistance should be able to carry without overheating the current at which the motor is rated, and should be perfectly smooth in action. It is mounted on the right-hand side of the cabinet, as indicated in the diagram.

Once again I must refer the reader to previous articles in this series as to the construction of the scanning disc and the mounting used for it. This type of mounting has been universal in all our apparatus, and I do not propose to repeat here what has already been fully dealt with. The mounting will be of the greatest assistance when other transmissions are being received, as one can change the disc with ease by the simple process of removing four screws.

The viewing lens is of the plano-concave type, and has a focal length of 6 inches. It is mounted on the front panel of the cabinet and held in position by the aid of a metal ring, 4¼ inches by 5¼ inches, constructed of 20 SWG sheet tin. Details are shown in Fig. 2.



Back view of Captain Wilson's receiver.

The Phasing Device.

We now come to the question of the phasing device to use. I think this is best

(*Continued on page 419.*)

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THAT WITZLEBEN TOWER

W. C. FOX

Has Another Scientific Adventure* over Berlin

SOMEONE, sometime, somewhere in some book or other, has called Fleet Street the "Street of Adventure." He was quite right, but he merely applied the term to one of the many streets which go to make up London. The whole city is the starting-off point of many adventures, the only necessary qualification being a willingness to undertake whatever offers, and a readiness to go anywhere by any means—at least, so it seems—and so it proved over this, the latest of a long series of adventures that have come my way in connection with scientific matters.

On a Monday morning about a month ago it became necessary for someone to go to Berlin in a hurry on a matter not entirely unconnected with the wireless exhibition there, and television.

This Passport Business.

As every ordinary means of passenger conveyance had left, flown, or otherwise gone to Berlin, there was nothing for it but to charter an air taxi. Securing the conveyance was only half the task, however; who was it to convey? As continental countries, together with our own, have a rather disproportionate regard for a document called a passport, the passenger had to have one of these documents, and, as I was the only fortunate possessor of one, the journey and its responsibilities fell on me.

A wild rush to gather up this all-important passport and a few clothes, and then to Croydon as fast as a taxi could go through London.

Arrived at Croydon, the one great question was, "What sort of a machine are we going in?" *i.e.*, the pilot, mechanic, and myself. As if in answer to the question the machine appeared from the hangars, taxi-ing to the filling station, an all-metal four-seater cabin monoplane, a slim, shining thing of beauty. Filling for the petrol tanks of the machine, and "fillings" at the buffet for the human beings who were to travel completed the preparations, and everyone climbed on board.

The Take-Off.

With scarcely any excitement or notice we were off. Our machine had a cruising speed of 110 to 120 miles an hour, with lots more speed, if needed; but even at this modest speed Croydon soon became a blurr on the horizon, and the pleasant fields of Kent passed quite rapidly—for an aeroplane—beneath our wings.

The flight to the French coast was without incident, except that the pilot in a moment of abstraction put his head out over the side of the machine and lost his hat, and followed this up by losing a map in the same way!

From Calais to Ostend we flew low over the waves, just clear of the beach, to the great annoyance of many swell dogs indulging in afternoon naps under innumerable deck chairs. Their barks of protest, however, were lost in the distance before they were uttered.

At Ostend, as we had no wireless, a couple of circuits were made of the aerodrome to let them know we had crossed the Channel in safety, otherwise an S.O.S. would have been sent out requiring all ships to look for a lost machine!

From Ostend a perfectly steady uneventful flight over the level land of Holland and Western Germany brought us to Hanover, just as the golden rays of the setting sun were throwing long distorted shadows of trees and houses across the fields.

From Hanover to Berlin, a journey which takes about an hour, there is a chain of "lighthouses" to guide wanderers home. The first of these we picked up shortly after leaving Hanover, a tiny winking light in the centre of a broad dark wood of pine trees. The light winked with the precision and sharpness of an electric spark, but seemed impossibly tiny. Before it had passed under our wings No. 2 had been spotted, shining through the misty haze in the distance, No. 3 almost immediately followed it, and thereafter each light was picked up, some flashing with the accurate "click" that one associates with German soldiers on parade, while others winked in a lazy, half-asleep manner. The whole formed a dead straight line that beckoned one on, and seemed to say: "You are all right, you can't go wrong if you trust us." And so we flew on while Germany gradually disappeared in the soft mists of evening and night, and the sky in the west grew from orange to deep blood-red, and then faded slowly to a cold faint glow.

The Lights of Berlin.

The last of the line was a higher, brighter light than any of the others, and went "wink," pause, "wink," pause, in a very stately and dignified manner, as befitted the most important beacon light in one of the principal cities of Europe. Simultaneously, the lights in the outskirts of Berlin came into view. We flew gaily on, knowing that we were expected, and that the aerodrome was in the heart of Berlin and a little to the south of the centre of it; but we knew nothing more.

By the time we had reached the final light all hands were looking for the aerodrome, expecting to see a blaze of light with landing signs and all the other adjuncts that form a so familiar part of Croydon—but there was nothing to be seen.

Away in all directions stretched the lights of Berlin, looking like innumerable strings of diamonds

* Our contributor seems to be a glutton for adventure. Our readers may remember the adventures which he described in our April and November 1928 issues.

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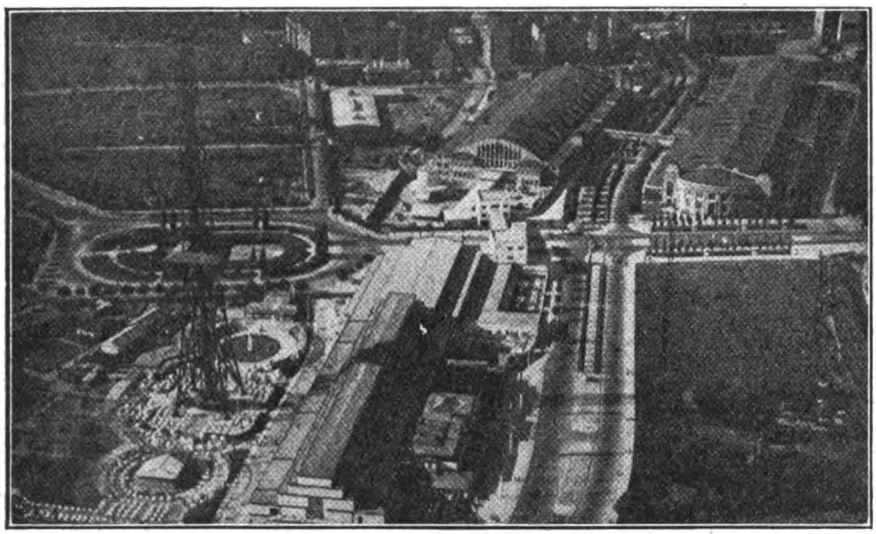
lying on black velvet, with here and there a ruby or turquoise standing up brighter and bigger than the others. Sundry blank spaces looked promising, but investigation of one revealed a suspicious shine from the surface of it; it was a lake, and another proved to be an unlit portion of the city full of house tops and other spikey objects. Neither were nice landing grounds for an aeroplane.

There was nothing for it, we were lost, and the only thing to do was to go back to our last beacon light and start hunting again. How I got to hate that light, with its stupid "flash," "flash," "flash," and not a word or sign of direction.

As we circled round it, we could see a number of buildings brilliantly lit up all round it, with crowds of people in the streets, while the ground on which it stood seemed to be laid out as an ornamental café and garden.



The Berlin Wireless Exhibition, and the Witzleben tower, as seen from the air. The height of the tower is 420 feet. There is a restaurant one-third of the way up.

Behaving something like an angry bee that has lost the way to its hive, we came down a few hundred feet and droned round it. No response. A black patch near by, that might have been an aerodrome, contained nothing more promising than a maze of railway crossings and lines. We flew off to try other places, but all looked equally uninviting, and as we took wider and wider circles over the city, which in its turn seemed to grow ever bigger and bigger, I realised, with a queer shiver that we had been flying for something like five hours, and our petrol must be getting low! You can't stop an aeroplane, get out, have a look round and then go on. If you are flying and there is no aerodrome or suitable field in sight, you have to keep flying, or, when you come down, take your chance of hitting something.

While wondering if it was possible to land in a street without upsetting things too much, the pilot twice circled over a dark patch that we had been investigating, and I caught the word "aeroplanes." Sure enough, there, looking like ghosts, were several aeroplanes, faintly reflecting the lights from a building. We circled the spot once, twice, three times, like a hungry child passing and re-passing a pastry-cook's window, or a wasp circling a jam dish that it has been chased off, and then a surprising thing happened, a large portion of the black space was marked out with neon tubes. A second after, someone in the centre of it fired off a green Very light, which soared up and then sank back to earth.

What did it mean? We were not quite sure, but it certainly showed that someone had seen us. We circled again, wondering if those neon tubes were on the ground, six, or sixteen feet up in the air, and anyhow, why didn't they switch on the flood lights?

As a further circuit brought forth nothing but another green Very light, the pilot decided to land.

Turning his back on what was apparently the aerodrome, he flew over Berlin for some distance, turned and began to come down, both himself and his mechanic looking over the sides of the machine, watching. The roofs and brightly lit streets came rushing up to meet us, and still we dropped lower and lower until it seemed we must hit the house tops. The sound of the engine died away to a mere murmur, and only the rush of the air past the wings was audible. "Your right wing is low, keep up a bit, there are houses under us," suddenly said the mechanic, and we rose a foot or two as the engine briefly barked in response. Then, "We are nearly touching—nearly touching—nearly—" and with the gentlest of bumps we were down and running over the ground to the hangars. There, feeling like heroes (at least, I did), we climbed out into the midst of a group of German officials. Were they greeting us? Not a bit of it! They wanted to know what business we had to land on the Tempelhof Field when they had been told very definitely that we had landed at Cologne an hour or so ago, and were not coming on that night? No machine was expected in at all.

We also had our grievance. Why wasn't the aerodrome lit up and some sign made to welcome a person in?

Cologne, it seemed, was quite positive we had landed there, and they knew all about us, although we had not been within a hundred miles of the place, or landed anywhere on our journey. In the circumstances, both parties decided to let Cologne make the best excuses it could, and bear the whole brunt of our joint annoyance.

"All's well that ends well," goes the saying, and when we had finished dinner we appreciated the truth of the proverb, for investigation showed that when we landed there was only enough petrol left in the tanks for about five minutes further flight!

The next night I found my irritating flashing light. It is on the top of the Witzleben aerial tower (138 metres high), and under and around it was the wireless exhibition that had called me to Berlin!

The Editor is very fond of that tower and light. He tells me he has used a photo of it to head his report on the Berlin Radio show.

To me it acted rather like a friend who refuses to speak when two words will help you out of a very awkward situation. My last sight of Berlin as the train carried me back to London was Witzleben's flashing light—calling more aeroplanes home.

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Television and your Wireless Receiver

By H. J. BARTON CHAPPLE, Wh. Sch., B.Sc. (Hons.), A.C.G.I., D.I.C., A.M.I.E.E.

Now that television is being broadcast we shall soon have television receivers in our homes, so it behoves us to consider whether our wireless receivers are capable of efficiently supplying a televisor. In the following article our contributor deals with several points of importance in this connection.

THE announcement that the Baird Television Development Co., Ltd., and the B.B.C. have come to terms in connection with the broadcasting of television from one of the Corporation's stations at an early date, has no doubt caused a flutter in the dovecots of the average wireless listener. The first thought that comes to his mind is sure to be "will my wireless set enable me to receive the television signals in the same way as I have received aural broadcasts. Or must I scrap my receiver for an entirely new one, or alternatively modify it?" This will be followed by a second thought of "what sort of power shall I require and must I use two aerials or is it possible to couple more than one set to my aerial and yet prevent interference one with the other?"

A Virgin Field.

Of course this will in no way exhaust the queries that will arise, but the purpose of this article is to try and point out where modifications are likely to be necessary, and also suggest a few lines whereby useful experiments can be undertaken and invaluable data derived which will be of great assistance in facing points that are sure to arise in connection with this almost virgin field of endeavour. The wireless man has been seeking new worlds to conquer, because with aural broadcasting nothing of an epoch-making character has occurred for a considerable period, just a steady progress in design with more attention being paid to details and a gradual awakening to possibilities with electric mains drive in lieu of accumulators and batteries. What a wonderful opportunity is offered, therefore, by "this television," a chance to display ingenuity with a reward out of all proportion to the time and energy expended. Brother fans, roll up your sleeves, you haven't a moment to lose if you want to be among the first who can claim to see as well as hear the television programmes on the air.

A Close Resemblance.

From the pages of this journal you have learnt ere this, that as far as the modulation of the high-frequency carrier wave of the transmitting station is concerned the method resembles closely that of ordinary speech broadcast. The photo-electric cell serves the same purpose in television as the microphone in aural working and the light pulses are changed to current pulses, amplified to the appropriate strength and, sent via the carrier wave, pass into space. It is reasonable to suppose, therefore, that a normal wireless receiver should be capable of rectifying and amplifying the resultant induced aerial currents and with a televisor replacing the loud-speaker, the current pulses can be re-converted into light pulses and enable images to be seen.

A Question of Power.

Let us analyse these general remarks carefully. On an average the power required to work a medium loud-speaker at comfortable strength is fairly small, unless of course one is using a moving coil instrument. Indeed, in many homes we find a two-valve receiver capable, under favourable conditions, of giving loud-speaker reception from two or three stations. Now in our televisor we must make this power operate the neon lamp, and it should be fairly clear that for this lamp to function successfully the power output from the set must be of reasonable dimensions. Of course, everything will depend upon the type of neon lamp employed, it being realised that the most common neon tube used for television purposes is the flat plate type.

Since these are now being made for low voltages we can say (without going into exact current and voltage details at this juncture) that if a receiving set is capable of giving signals of **good** loud-speaker strength from a particular transmitting station, then it will be capable of giving a clearly visible picture on the televisor when receiving signals from the same station. You know that it is possible to watch the neon lamp flicker with quite small imputs—substitute a neon lamp for the loud-speaker on your own set and see for yourself—but this would only mean a faint picture in the televisor and obviously this is not what is wanted. Our first criterion for successful television reception from any given station, therefore, is good or strong loud-speaker strength, it being appreciated that the television note itself has a characteristic sound of its own and if preferred the signal may be tuned in on the loud-speaker and a change-over effected to the televisor afterwards.

What of the Detector?

Another important detail which merits consideration is the type of

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rectification employed, that is, whether grid leak or anode bend. Even with ordinary broadcasting, controversy has raged around this point, but the real facts of the case can only be ascertained if it is approached with an unbiased mind. The detector valve in a wireless

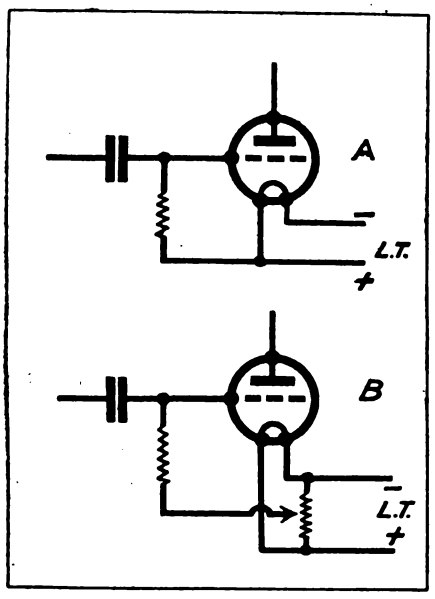

Fig. 1.
Two methods of connection for leaky grid rectification.

set has only high frequency oscillations applied to it, and it converts these into a pulsating unidirectional current which usually is amplified by further stages of valves coupled in cascade. The amount of modulation of the high frequency carrier is varying throughout the time of a broadcast, but steps are always taken to prevent the wave being over-modulated as this would only introduce distortion.

Now the range of frequencies to be covered extends in the case of speech and music from about 30 to 10,000 cycles, and while it is advantageous to go beyond this top limit for television purposes in order to produce greater detail, the nine kilocycle sideband limit which is in operation is capable of giving pictures which abound with a wealth of detail. No doubt in the future, television broadcasts will have special allocations as far as sidebands and wavelengths are concerned, but that does not concern us at the moment. We must see that the set in use is capable of passing the nine kilocycle band without distortion to the detector valve, and this in turn must deal faithfuly with the signal and give an output which is in no way distorted, otherwise of course the picture will not be perfect.

Which is Best Suited.

A full analysis of detection is a lengthy proposition, so we will confine ourselves to salient points in order to find which of the two methods—grid leak or anode bend—is the best suited to television reception. In the case of the former, rectification takes place in the grid circuit of the valve, and the resultant low frequency currents undergo magnification in the valve itself, whereas with the latter the reverse holds, that is, the high-frequency currents are amplified in the valve first and are then rectified in the plate or anode circuit. The usual connections of the grid leak rectifier are shown in Fig. 1 (*A*), a fixed condenser of about ·0002 to ·0003 mfd. being inserted as shown, to offer a high impedance to low-frequency currents, while the valve grid is connected via a resistance of about two megohms so that grid current flows. On receiving the high-frequency signals, oscillations pass to the grid through the small grid condenser, but owing to the high impedance of the grid leak, and to the varying grid current produced by the signal, the grid voltage varies in accordance with the low-frequency portion of the signal. Actually, the grid condenser when working collects charges of electricity which reduce the normal grid voltage and, of course, the anode current reduces in sympathy.

A Fall in Current.

That is to say, if a milliammeter is connected in the detector plate circuit the reading will decrease when receiving a signal. In addition to the fact that in grid leak rectification the valve must be adjusted so that grid current can flow, there should be ample provision made for plate circuit changes. In other words, the high tension must be so adjusted that the valve also works on the **straight part** of its plate current grid voltage characteristic and excursions must not be made into the curved portions of the characteristic or a secondary rectification will take place (actually anode bend) and distortion occurs.

Furthermore, it is frequently of great advantage to be in a position to adjust very carefully the grid voltage and to this end the arrangement shown in Fig. 1 (*B*) is used, a potentiometer being applied across the L.T. and the end of the leak taken to the variable tap. Arrange the value of the grid leak and the voltage so that the grid is working on the most sharply curved portion of the grid current curve. Examine the valve curves usually included in the carton as this will assist you in making accurate adjustments, and a reference to Fig. 2 will show what is meant from the valve curve point of view.

How Distortion Occurs.

Now when a strong signal is impressed upon the grid using this system of rectification, the grid circuit is liable to choke and distortion arises, but with relatively weak signals the system is most sensitive and gives good results. Again, with the condenser present in the grid circuit there is likely to be frequency distortion, for with increase of frequency (and we have seen that it is the higher frequencies which add to the wealth of detail in a television picture) the impedance falls off. Improvements can sometimes be effected by lowering the value of the grid condenser or grid

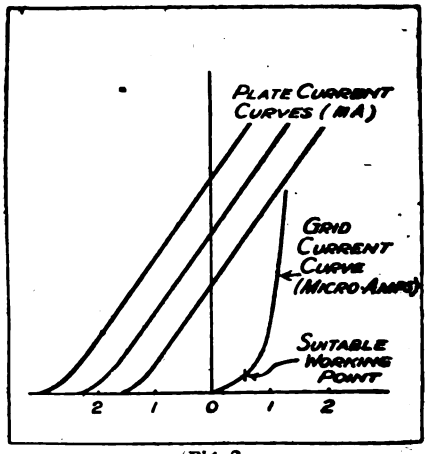

Fig. 2.
A typical family of valve curves.

leak or adjusting both grid and plate voltages. The inclusion of a small condenser between plate and filament (about ·0003 mfd.) must not be overlooked, but if a form of capacity reaction is in use then this will not be necessary.

Anode Bend Rectification.

Coming now to anode bend rectification, as was mentioned

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earlier, the high-frequency signal is amplified first and then rectified in the plate circuit, and in this case care must be taken to see that no grid current flows. We use the bottom bend of the anode current

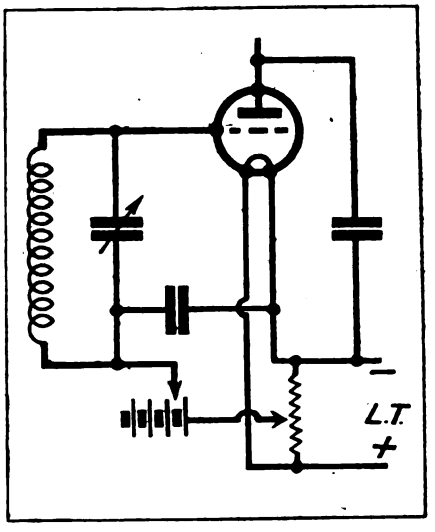

Fig. 3.
Circuit arrangements for anode bend rectification.

grid voltage characteristic to do the rectification, and in consequence sufficient negative grid bias must be applied to work at the proper point, the exact value being contingent upon the plate volts in use. The signal variation on the grid must not produce grid current, otherwise distortion will occur and this criterion is a good guide to making the appropriate adjustments. Fig. 3 shows one way of connecting up the valve for this type of rectification, the potentiometer in conjunction with a grid bias battery giving a fine control of the biasing voltage required, and tests can be carried out under working conditions.

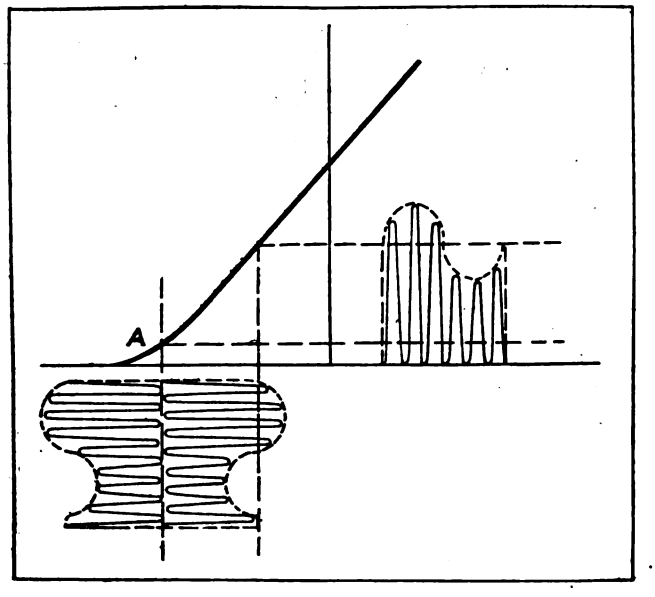

Fig. 4.
How rectification takes place.

Fig. 4 shows in a simple manner how rectification takes place with a modulated high-frequency carrier wave applied to the grid. With the negative biasing voltage adjusted so that normal working is at *A* then the resultant plate current change is taking place on the **straight part** of the characteristic and little or no distortion occurs. If the modulation is too strong or the plate and grid voltages are too low, it is quite obvious that the grid swing will run on to the positive side of the characteristic and grid current flows, with resultant distortion. On the other hand, if signals are weak the curved part of the characteristic is used and distortion again takes place since there are not proportional plate current changes to grid voltage changes. The use of an anode circuit by-pass condenser is usually essential, although this has a tendency to weaken the higher frequencies.

Which is Best.

It should be quite obvious that with strong signal imputs to the grid, anode bend rectification lends itself to almost distortionless rectification and, consequently, better picture reproduction is obtained. On the other hand, for weak signals grid leak rectification is to be preferred. What then is best suited to the requirements of television? For all-round working anode bend rectification is preferable for two or three reasons, and having grasped the fundamentals of both types of rectification the reasons for this will be advanced next month, while the other points mentioned in the opening paragraphs of the article will also be dealt with.

National Radio Exhibition,
New Hall, Olympia.
Sept. 23rd. — Oct. 3rd.
Visit us at
GALLERY STAND
No. 241

STATEMENT FROM THE BAIRD CO.

At the time of going to press we learn that the Baird Company are making arrangements with manufacturers for the production, under licence, of television receiving sets which should, after preliminary tests through 2LO, be standardised and made available to the public.

In our next issue we hope to be in a position to give our readers some further information.

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The Television Society

Latest Correspondence *re* Broadcasting. Group Centres. Autumn Programme. Olympia.

THE Television Society was two years old on the 7th of last month. Its first meeting was held immediately following the British Association Meeting of September, 1927, in the University Buildings, Leeds.

Since then enthusiasm has been maintained, and its membership is now over 550 members.

Lectures have all been well attended, and the summer visits proved a great success.

The change of address of headquarters to 4, Duke Street, Adelphi, W.C. 2, has evidently proved helpful to members, as its central position has enabled visitors to interview the Society's officials on all phases of television progress.

During the vacation circulars have been distributed to members, notifying them of progress towards establishing the broadcasting of television, and it will be seen from the following correspondence that the experimentalist at home will soon be afforded his opportunities.

The following completes the correspondence already circularised :—

BAIRD TELEVISION
DEVELOPMENT CO., LTD.,
133, Long Acre, W.C. 2.
10th September, 1929.

W. C. KEAY, Esq.,
The Television Society,
4, Duke Street, Adelphi, W.C. 2.

DEAR MR. KEAY,

As promised, I beg to enclose copy of a letter sent to the Postmaster-General on the 4th inst. in reply to the offer of increased broadcasting facilities of five half-hour periods per week. I do not think I can usefully add anything to the statements made in the letter, which clearly indicate that the present facilities have been accepted as a temporary measure.

Yours sincerely,
(Signed) T. W. BARTLETT.

Copy of letter from Baird Television Development Co., Ltd., to the Postmaster-General, dated 4th September, 1929.

SIR,

I beg to acknowledge the letter of Mr. Leach of the 14th August, 1929, and to thank you for it.

My Board desire me to let you know that, whilst they are of the opinion that the offer now made is inadequate and will not in any way satisfy the wireless trade that they are justified in embarking upon an extensive programme of manufacture, my Board have no other alternative but to accept the offer as a temporary measure to enable my Company to give demonstrations to manufacturers interested in becoming licensees, and representatives of foreign countries who desire to see our system working under ordinary broadcasting conditions. In the light of the results of these demonstrations the whole matter can be reopened and reviewed with a view to adequate facilities being granted, and thus making it possible for manufacturers to go into production and sets being made available to the public.

My Board desire to enlist the aid of your Department in initiating the necessary consultations with the British Broadcasting Corporation so that a service may be put into operation without the unnecessary delay of a day.

I have the honour to be, Sir,
Your obedient servant,
(Signed) O. G. HUTCHINSON,
Managing Director.

Group Centres.

Interest has been excited by the impending developments of the broadcasting situation, and members in the country and others have expressed the desire to meet locally, attend lectures and discussions, and generally aid and intensify the objects of the Society.

To meet this demand the Council has drawn up a statement of procedure, also bye-laws for the formation of group centres.

A typed copy will be forwarded to members interested, on their application to headquarters.

Arrangements are being made so that secretaries of group centres may receive advance lectures or abstracts for discussion on the same date as the London meetings. Societies, or members wishing to form a group centre of the Television Society, should apply to the undersigned for further particulars.

The work of the Society has steadily proceeded during the vacation. The index of literature has grown to over 700 references which are being very carefully scrutinised. The work of compiling has proved to be more than originally contemplated, but it is expected that publication may be put in hand during the autumn.

In connection with the "standardisation of terms," representatives of the Television Society have been elected to serve on the committee of the British Engineering Standards Association.

The last published proceedings include reports of the two last informal meetings, when discussions were held on Selenium, and on the Quantitative Aspect of Television. This has been forwarded to all the Fellows. A limited number of copies remain, priced at 6d. each, which will be forwarded to members who apply.

It is gratifying to note that the Treasurer reports that the year's subscriptions are coming in, as so

(*Continued on page 419.*)

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The Actino-Dielectric Effect

By H. WOLFSON

Hitherto our contributor has dealt with the photo-electric effect in connection with metals. It is not generally known that similar effects take place when certain non-metals are exposed to light. In the following article Mr. Wolfson gives some interesting details.

THE present article is the outcome of the request of a number of readers for further information concerning the actino-dielectric effect. This was mentioned briefly in an earlier article,* and readers would be well advised to read that article in conjunction with the present one.

The actino-dielectric effect was the outcome of investigations of the photo-electric effect of non-metals, usually insulators, or substances of extremely high electrical resistance. It seems, therefore, desirable to discuss this at some length, as in our previous study of the photo-electric effect little or no mention has been made of this subject.

The detailed investigations of Goldmann and Kalandyk into the photo-electric effect of sulphur will be described first. Many of the peculiarities of sulphur are shared by other insulating substances, and this will be pointed out in the course of the article.

Conductivity of Insulators.

If one is dealing with a comparatively thick layer of sulphur or other photo-active insulator it would be expected that electrons would be liberated, not only at the surface, but also in the interior of the substance. These latter electrons, since they would not be emitted, should impart to the insulator some degree of conductivity during illumination. The experiments of Goldmann and Kalandyk support the view that these substances have temporarily a number of *free* electrons, which account for the observed conductivity.

The experimental arrangement for the investigation is extremely simple, consisting of a piece of sulphur arranged between two electrodes. The arrangement can be imitated by graphiting the surface of a smooth piece of slate, which is divided into two electrically distinct portions by means of an engraved line, of a form as shown in Fig. 1A. No graphite

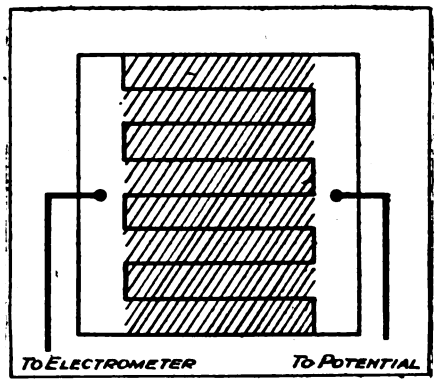

Fig. 1a.

Shows slate former, for sulphur or selenium type cell. Shading shows sulphur.

should be allowed to get into this dividing line, which should not exceed 1 mm. in width. After testing with an H.T. battery and phones to make sure that there is no electrical connection between the two halves, the slate can be coated with sulphur by simply heating the slate, carefully, over a Bunsen flame, and painting the sulphur over the surface embraced by the lines. Contacts are arranged at the sides, and can be either springy brass clips or clamps such as are used in primary batteries.

Light is incident on the sulphur at right angles to the plane of the slate, and should be from a powerful source, such as the carbon arc, already described, or a mercury-vapour lamp. It was found that the sulphur acquired a conductivity which was independent of the applied field up to 400 volts per mm. The current passing through the sulphur is then of the order of 2×10^{-9} amp.

An alternative arrangement (Fig. 1B) consists of a metal plate *P*, on which is placed the sheet of sulphur or other insulator *S*. The gauze *G* is placed parallel to the surface of the sulphur. The gauze can be maintained at any potential, either positive or negative. In the latter case the electrometer will acquire a negative charge, due in part to the photo-electrons emitted from *G* to *S*, and partly to the conductivity produced in the thin layer of illuminated sulphur.

Should the layer be of such a thickness that the illumination does not reach *P*, then there will be a separation of charges until the external field is counteracted. This is called the polarisation of the dielectric, which is indicated when the negative charge on the electrometer becomes constant after the lapse of a certain time.

With the gauze at a positive potential, however, the positive charge on the electrometer is due: (*a*) to the conductivity induced in the sulphur (if thick layer, polarisation effects come into play), and (*b*) to the escape of any photo-electrons present in the sulphur, from *S* to *G*.

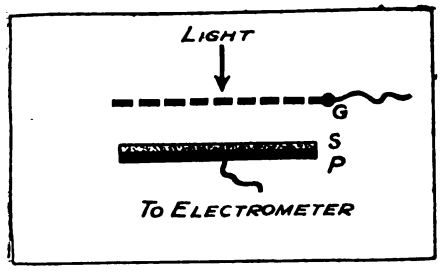

Fig. 1b.

An alternative arrangement.

Only when the layer of sulphur is so thin that it is a conductor throughout the experiment is the steady current due entirely to the surface photo-effect.

* TELEVISION, No. 13, March 1929, p. 40.

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Without entering into a discussion of the curves, I append Fig. 2, which shows the behaviour of a 2 mm. layer of sulphur, with the distance *S–G* 3 mm., under two sets of conditions: (1) gauze negative and (2) gauze positive. Fig. 3

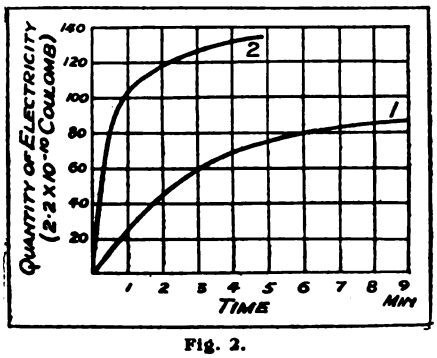

Fig. 2.

1 = Gauze at negative potential.
2 = Gauze at positive potential.

shows the effect of the thickness of the layer. We see that the effective depth of penetration of the light is about 0·3 mm.

It is difficult to state the ratio of the number of electrons emitted by the surface to the number released in the illuminated layer. From the results obtained, however, it seems permissible to suppose that more electrons are liberated *in* the illuminated layer than *from* the surface. The question of the effect of wave-length has, unfortunately, been neglected. Goldmann mentions that the effect is cut off entirely by a glass plate, which suggests that light of wave-lengths shorter than 3,300 Å alone are effective in producing the surface effect, and that longer waves suffice to produce the conductivity.

Conductivity of Selenium.

It is well known, of course, that selenium becomes a conductor when illuminated by visible light, yet its photo-electric effect is not displayed till a wave-length of 2,200 Å or less is employed. The work of Ries leaves little doubt that the conductivity arises, in part at least, from the free electrons. Nevertheless, it seems to be definitely established that the escape of photo-electrons from many non-metallic surfaces requires light of higher frequency than is required to produce an increase in conductivity.

This view seems to be amply supported by the work of other experimenters on silver iodide, anthracene, and Lenard and Saeland's experiments on luminescent substances. The apparatus employed was similar to that shown in Fig. 1B. It is shown that the change in conductivity in the illuminated sheet of an insulating substance can only produce the polarisation effect when the layer which is rendered conducting is not in contact with the metal plate. The electrometer does not acquire its charge at a constant rate, but the rate of charging decreases to zero, indicating that a final polarisation state has been reached. This is the so-called actino-dielectric effect, a name given to differentiate it from the true photo-electric effect, in which the electrometer acquires charge at a constant rate. The syllable "di" in actino-dielectric is meant to stress the essential difference between the effect and the analagous changes in selenium.

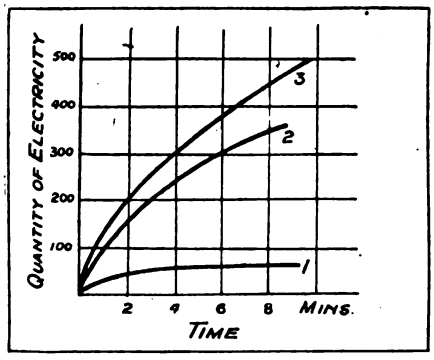

Fig. 3.

Showing the effect of thickness:

1 = Thickness of sulphur .. 1 mm.
2 = " " .. 0·5 mm.
3 = " " .. 0·2–0·3 mm.

The latest conclusions of such workers as Oeder, Schmidt, and Lenard is that the actino-dielectric effect has no connection with phosphorescence. It should, in a dielectric displacement and formation of residual charge, be accompanied by a definite wandering of ions, which is particularly shown in long wave-length red light.

In the formula $V = kv - V_0$, which connects potential with maximum emission velocity and frequency, we regard $V_0 e$ as the energy required by an electron to be separated from the surface molecules. If less energy is required to separate an electron from an interior molecule than from a surface molecule, we should expect the increased conductivity which is produced to be brought about by light of longer wave-length (lower frequency) than is requisite for the photo-electric effect.

From time to time various workers have carried out experiments with a view to finding the connection, if any, between the photo-electric effect and the fluorescence of a number of substances. Pauli employed an interesting and novel method for the investigation of the problem. The ratio of the intensity of the exciting light to the fluorescent light was studied as a function of its relation to the wave-length of the exciting light. The photo-electric effect was examined at the same time, and it seems reasonable to expect that if there is a real and fundamental relation between the two effects, we should expect a marked photo-effect with the most active exciting light.

Electrometer Tests.

A shallow metal tray was connected to an electrometer. Around the tray was a cylindrical electrode, which could be raised to any desired potential, either negative or positive. The fluorescent substance is placed on the tray and illuminated. The substances examined all showed well-marked actino-dielectric effects. A typical case for eosine is given in Fig. 4. The two curves give the progress of the leak of the electrometer with time, the cylinder being at a negative or positive potential with regard to the illuminated substance.

If the surrounding field is positive (thus favouring the escape of negative electricity, in the shape of electrons), the actino-dielectric effect disappears

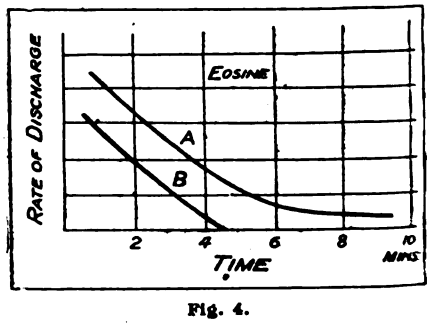

Fig. 4.

A = Surrounding cylinder at positive potential.
B = Surrounding cylinder at negative potential.

after a time, leaving the ordinary photo-electric effect.

If we call the photo-activity of a standard zinc plate 2,000, the activity of anthracene was the

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greatest, of value 10, while eosine was least active (1·2). The next graph (Fig. 5) shows (1) the actino-dielectric effect and (2) the efficiency of the light for exciting fluorescence plotted against the wave-length. No relation at all is shown for anthracene, the maximum for the actino-dielectric effect was at 5,400 Å, and for the efficiency of the exciting light the maximum was at 4,450 Å.

Turning our attention now to phosphorescent substances, such as have been examined by Lenard and Saeland, we find further evidence of the actino-dielectric effect. It was in this connection, in fact, that the term was first employed. Quoting from the original paper by these two workers:

"When the specimen was illuminated with light containing red as one of its constituents the electrometer gave a deflection when the

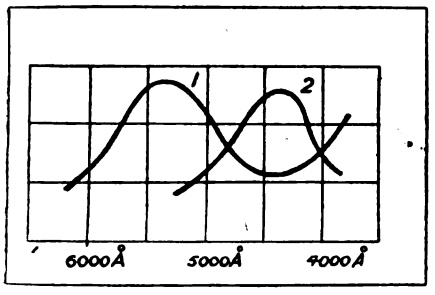

Fig. 5.
1 = Actino-dielectric effect.
2 = Efficiency of light for exciting fluorescence.

specimen was positive. In the case of a positive charge, however, the deflection increased to a limiting value, and then remained constant; while when the specimen was negative the deflection continued to increase as long as the illumination lasted. When the specimen had been exposed to red light long enough for the electrometer needle to have come to rest the phenomenon could not be observed again until the specimen had rested for several hours in the dark, or in some other way—e.g., by heating—had been restored to its original condition. But if the experiment was performed with the gauze alternately positive and negative, it could be repeated indefinitely. With violet light no deflection was observed unless the gauze was positive. . . ."

The authors point out that the phenomenon suggests either dielectric polarisation or temporary conductivity under the influence of the longer rays.

The substances studied, called "phosphors," consist of a sulphide of calcium, strontium, or barium, to which is added a trace of metal such as lead, bismuth, or nickel. The whole is fused together with the aid of a flux, which may conveniently be sodium sulphate or borax. The most active of these phosphors is calcium sulphide, with bismuth as the added "impurity"; the photo-electric activity is nearly as big as that of aluminium, but the maximum emission velocity did not exceed that corresponding to 2 volts. Since all these substances are good insulators, they show the actino-dielectric effect, which is, however, only noticeable during the first few minutes of illumination. The surfaces become charged up positively, until no further emission of photo-electrons can take place.

It was found that at the time when the surface ceases to emit any more electrons only one-tenth of the surface was actually charged. From this it seems fairly safe to conjecture that the photo-electric effect is not distributed evenly over the surface, but is localised in those centres which are active in the phosphorescent sense.

The Construction of Amateur Apparatus.

(*Concluded from page* 410.)

constructed on the following lines: The motor should be arranged to rotate about its axis, this motion being imparted to it by means of a worm drive. The case of the motor should be mounted in two independent bearings. As this sort of work requires a considerable amount of skill, and entails the use of machine tools, I do not propose to give details here. It should be noted that this method of phasing can only be used when some form of synchronisation is employed; where hand-controlled motors are used, a slight speeding-up or slowing-down of the motor will bring the picture "into phase."

In my next article, which I think will prove an interesting one, I am going to describe the construction of a filter for attachment to the output terminals of a radio receiver, having as its object the production and maintenance of the "glow" of a neon tube. Once the tube is "struck" and kept glowing its brilliancy can be varied by the signals fed into the filter by the radio set.

Television Society.

(*Concluded from page* 416.)

much of the future work of the Society must depend on the support it receives from its members.

The programme for the forthcoming half session is as follows:—

TUESDAY, October 1st, 8 p.m.—H. S. Ryland (Fellow, Optical Society): "Talking Films" (with demonstration).

TUESDAY, November 5th, 8 p.m.—F. Langford-Smith, B.Sc., B.Eng.: "Amplification and Television" (with experiments).

TUESDAY, December 3rd, 8 p.m.—G. Priechenfried, Esq.: "The Problem of Synchronisation in Picture Transmission."

TUESDAY, January 7th, 8 p.m.—E. George Lewin, M.Sc.: "Television—Some Suggested Schemes" (slides).

Next Meeting.

On October 1st the first meeting of the session will be held at the Engineers' Club, Coventry Street, W.C. 2, as usual, and the meeting will be preceded by an informal meeting for discussion at 7 p.m. During the evening it is hoped that the remaining half of the sessional programme will also be discussed.

The Radio Exhibition, Olympia.

Members may be afforded an opportunity of meeting each other, or officials of the Society, by making themselves known at the stand of the Television Press, Stand No. 241. It is expected that members will introduce the work of the Society to their friends and so help to augment the membership, and make for the success of group centres in the provinces.

J. DENTON, A.M.I.E.E.,
W. G. MITCHELL, B.Sc.,
Joint Hon. Secretaries.

Newcastle Group Centre.

Mr. B. B. Brooke, of "Holnon," Runnymede Road, Ponteland, Newcastle-on-Tyne, an enthusiastic Fellow of the Television Society, is endeavouring to form a group centre at Newcastle. His efforts have met with the whole-hearted support of the local Press, and we wish him every success.

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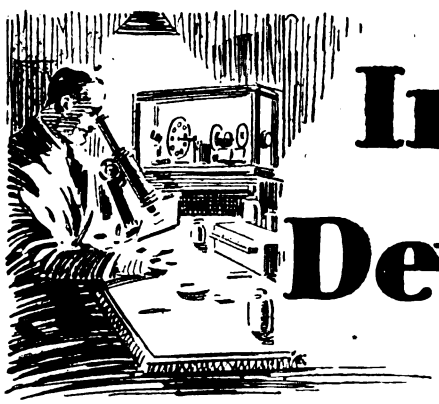
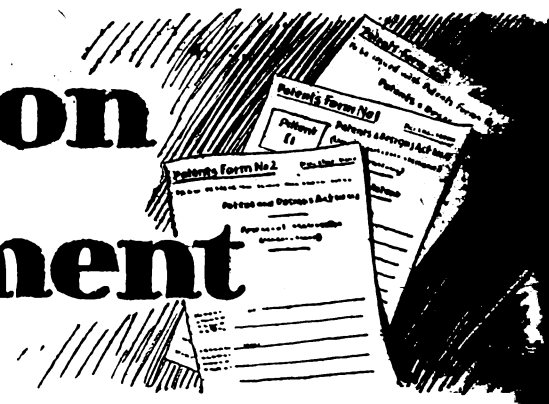


Invention and Development



The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. each.

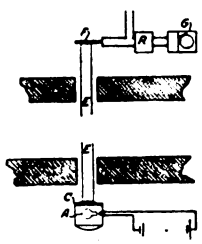


FIG 1.

Patent No. 313,178 granted to Neale, J. In a burglar alarm system, in which the shadow of the burglar causes changes in the resistance of a light-sensitive bridge, a lamp (A) with a screen (C) is used to direct infrared rays (E) on to the light-sensitive bridge (F). This bridge controls through a relay (R) a local circuit containing an audible or visible warning device (G) and/or photographic apparatus for taking moving or still pictures.

Protection is sought in *No.* 313,127 (Convention date, Germany, June 7th, 1928), by Lorenz Akt.-Ges. for an optical system to be used in picture telegraphy apparatus. In Fig. 2 the cylindrical drum on which the picture is wrapped is shown in the lower portion of the diagram. Light from a source (l) is concentrated by lens (ls1) to a point (p) on the surface of the picture and the reflected light is gathered by an annular lens system (shown in section as ls2) and then again reflected) by a pierced mirror (sp) on to a photo-cell (ph). The mirror (sp) may be curved. It should be noted that the piercings in the mirror (sp) and the lens system (ls2) accommodate the incident light beam.

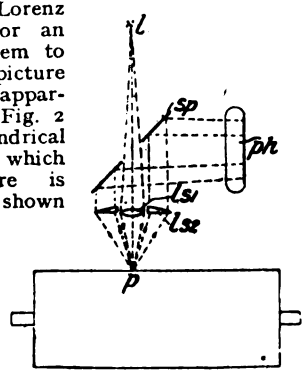


FIG 2

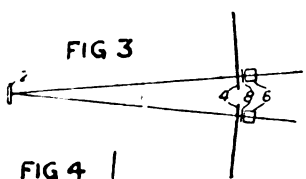


FIG 3

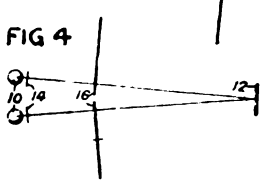


FIG 4

Patent No. 312,560 granted to Baird, J. L., and Television Ltd. (Divided on No. 312,406.) Television apparatus for colour reproduction comprises a transmitter (Fig. 3), with two or more exploring discs (4), each exploring an object (2) and each associated with a separate light-sensitive cell (6) having an appropriate light filter (8). In the receiver shown in Fig. 4, two or more light sources (10), each associated with a separate exploring device (16) and light filter (14) reproduce an appropriately coloured image (12). The exploring discs may overlap.

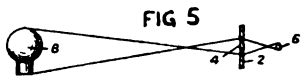


FIG 5

Patent No. 312,406 granted to Baird, J. L., and Television Ltd. (Fig. 5). In a television receiver employing a modulated light source (8) and a rotating disc (2), an optical system having a focal length of about one quarter of an inch or less and operating in combination with the exploring disc, limits the angular dispersion of the emergent rays. The short focus lens (4) placed in each aperture of the disc, is preferably cylindrical so as to expand the image (6) of the light source to a length equal to the width of the bands in which the reproduced image is explored.

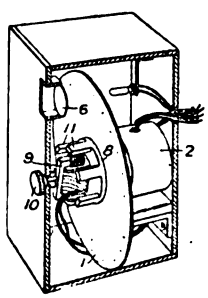


FIG 6

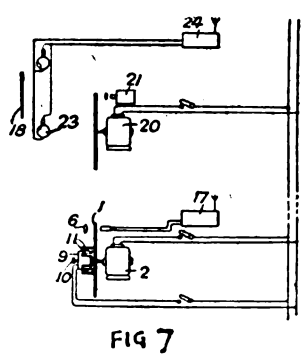


FIG 7

Nos. 312,651, 312,653, 312,654. Protection is sought in these three Patents by The British Thomson-Houston Co., Ltd. (Assignees of Kell, R.D., all bearing Convention Date (U.S.A.), May 29th, 1928) *No.* 312,651 (Fig. 6). The exploring disc of a receiver has an electro-responsive device arranged to lock the disc in synchronism with the exploring disc at the transmitter, the device being controlled manually to adjust for phase. For this purpose the disc at the receiver has a rotor (8) mounted on it, which co-operates with an electro-magnet (9). The rotor has a number of pole pieces (11). At the transmitter (shown in the upper portion of Fig. 7), light from a source (21) is reflected from the picture (18) thence to light-sensitive cells (23). The driving motors (20) (2) at transmitter and receiver respectively, are run from the same source of supply or from supplies of the same frequency. *Patent No.* 312,653 (Fig. 8). Received vision signals are impressed on the electrodes (3) (4) of a Kerr Cell (5). The exploring disc (9) is placed between the Kerr Cell and the light source, so as to restrict the light falling on the cell. The source of light (6) projects a beam through the lens (8), a hole of the disc (11), through the Kerr Cell (5), the lens (12) and is finally focussed on the receiving screen (7). *Patent No.* 312,654 (Fig. 9). The particular interest of this Patent is the means employed for collecting and concentrating the reflected light on to the light-sensitive cells.

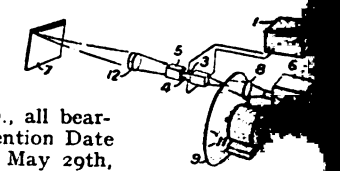


FIG 8

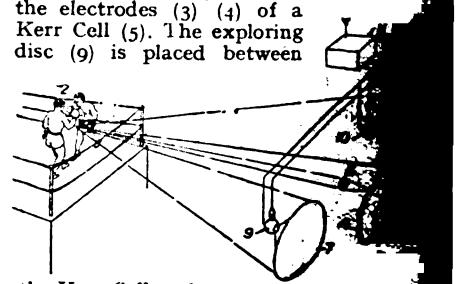


FIG 9

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Television

The Official Organ of the Television Society

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THE TELEVISION SOCIETY

The Television Society was founded on September 7th, 1927.

The Society makes its appeal to those who desire to share in the responsibility of furthering this new branch of applied science.

THE OBJECTS OF THE SOCIETY

may be summarised as follows:

(*a*) The Study of Television and its application in applied science and industry.

(*b*) To afford a common meeting ground for professional and other workers interested in current research relating to Television and allied subjects and to afford facilities for the publication of reports and matters of interest to Members.

(*c*) To encourage the formation of *Local Centres* of the Society in the Provinces, so that by social intercourse and discussion among members these aims may be more fully realised.

The present register indicates a world-wide membership.

ORGANISATION

The Society consists of one Honorary Fellow, Fellows and Associates, and the management is vested in a Council of Fellows, including the President, three Vice-Presidents, and Ordinary Fellows.

FELLOWS.—Ordinary Fellows must be elected by the Council. Candidates for the Fellowship must be proposed by two Ordinary Fellows, the first proposer certifying his personal knowledge of the candidate.

ASSOCIATES.—Any person over 21 interested in Television may be eligible for the Associateship without technical qualifications, but must give some evidence of interest in the subject as shall satisfy the Committee.

STUDENT MEMBERS.—The Council have arranged for the entrance of persons under the age of 21 as Student Members.

SUBSCRIPTIONS.—The annual subscription for Ordinary Fellows is 20s., with an entrance fee of 10s. 6d.; and for Associates 10s., with an entrance fee of 5s.

The annual subscription for Student Members is 5s., entrance fee 2s. 6d.

LIFE MEMBERS.—Life Membership may be secured at a fee of £10 10s.

MEETINGS.—The ordinary meetings of the Society are held in London at the Engineers' Club, Coventry Street, W.1, at 8 p.m., on the first Tuesday of the month (October to May inclusive). Notices of meetings are posted to all members about seven days before the meeting.

Full-size reproduction of the new Television Society Badge, which is available to accredited Members, and may be obtained from the Head Office, price 1s

The official organ of the Society is "Television," published monthly by the Television Press, Ltd., 26, Charing Cross Road, W.C.2.

A memorandum for the guidance of members wishing to form a Local Centre of the Society may be obtained (gratis) on application to the Joint Hon. Secretaries, 4, Duke Street, Adelphi, W.C. 2.

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Representative Greetings

From the OLD WORLD :

"The appearance of your twenty-first issue is an event which can hardly fail to interest all connected with the radio industry. It is noteworthy that whereas, in the case of the cinematograph, pictures preceded 'talkies,' the reverse has been the order in radio.

"Nevertheless the relationship between sight and sound is as obvious in the one case as in the other and no one can doubt that the perfection of television will result in the linking up of the two.

"Radio engineers rejoice that research and experiment in regard to television proceed unceasingly and they recognise with appreciation the valuable part your journal plays in constantly stimulating and maintaining interest in a matter so closely allied to their own work. They offer hearty and sincere congratulations on the work you have accomplished so far, and trust that the future will see a more rapid development than you anticipate at present."

Jno. T. Mould

Chairman of the
Radio Manufacturers' Association.

From the NEW WORLD :

"My sincere wishes that your publication may stimulate and inspire those working on Television to greater efforts in bringing to the world the benefits of this new wonder of science."

M. H. AYLESWORTH,
President,
National Broadcasting Company,
New York.

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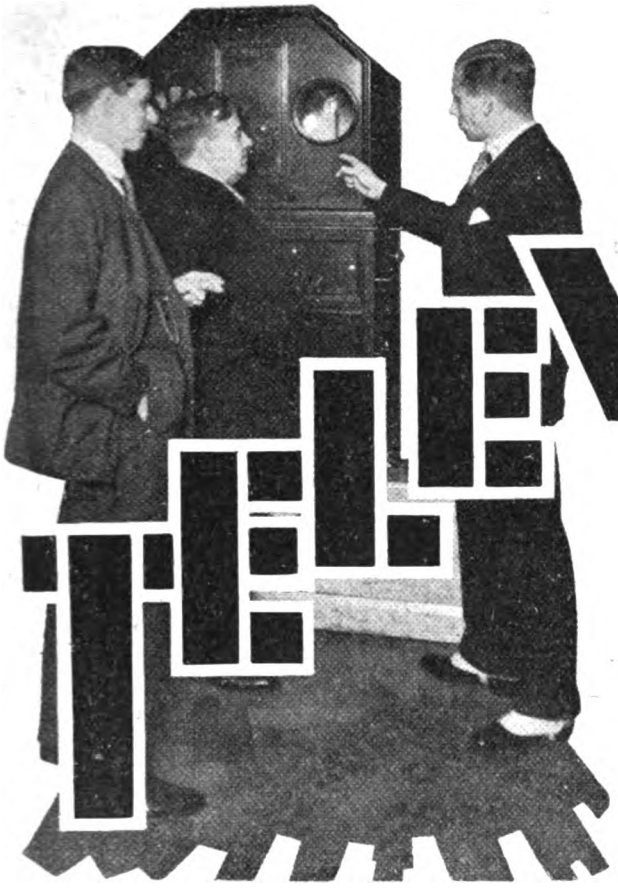

TELEVISION

THE OFFICIAL ORGAN OF THE TELEVISION SOCIETY

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VOL. II] NOVEMBER 1929 [NO. 21

EDITORIAL

THIS is our twenty-first issue. In its pages will be found messages of goodwill from men prominent in the public eye. Their interest in the achievement and progress of television has its counterpart in the realisation by the general public that this timely invention will bring to broadcasting the new life it so desperately needs.

Attention has been drawn in the Press and elsewhere to its future possibilities and applications. Such considerations have been responsible for diverting attention from the fact that television is already here in a practical form. Throughout the tedious struggle which has resulted in the present broadcasts of television from 2LO, it has been widely realised that the *real* difficulties contributing to the delay were not so much technical as they were matters of disposition on the part of those controlling an ether monopoly.

There remains much misgiving as to the cause of the delay in giving this thing to the public. It were natural to assume that, given initial finance, the placing of apparatus upon the market is a comparatively easy proposition. But behind and beneath all efforts to that end there are currents and cross-currents which have their origin in the peculiar ramifications that characterise the radio industry of this country. These are deep-rooted and they must be reckoned with.

The immediate development of television in Britain does not depend upon the efforts of any one organisation, or, for that matter, of the public. The situation calls for intensive co-operation between interests that have hitherto seemed, if not at war, then definitely at cross-purposes.

It is not for the B.B.C. to decide that television shall be withheld from the public. Neither is it for the Baird Company to decide that it shall be given to that public. Had that been the case, television would already be in our homes. No, that is not the answer.

It rests with the radio manufacturers to decide whether this thing shall be given to the public just as it is for the B.B.C. to supply the necessary service on the ether in order that British televisor receiving sets may be sold.

In the light of these facts let us look at the nature of the present television broadcasts.

The time chosen by the B.B.C.—between 11 and 11.30 in the morning, when most of us are at work—is not calculated to stimulate public interest. Meanwhile,

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a definite effort is being made still further to reduce the value of these transmissions from the public's point of view; on the one hand, by dubbing them "experimental" transmissions, thereby giving the public the impression that their continuity is entirely problematical (and therefore rendering the advisability of purchasing any receiving apparatus extremely uncertain), and, on the other hand, by insisting that the public demand for a television service is the only ground upon which their continuation can be assured.

But happily for television, there are more hopeful signs than these. The radio manufacturers who have been given the opportunity of *seeing for themselves* what can now be accomplished by television, are about to take matters into their own hands by demanding a proper television service. They realise that if the public are to be asked to pronounce their judgment on television, they must be given the opportunity of *hearing* the artists they can *see*, or, shall we say, *seeing* the artists they can at present only *hear*.

Wireless dealers throughout the country must be given an equal opportunity of picking up the television broadcasts in their home-towns; in other words, those resident in the Manchester area must be given similar facilities to those available to residents in the London area. The radio dealer, more than anyone else, realises that if only he can get a televisor working in his shop-window his sales will go up by leaps and bounds. Here again there are powerful influences at work which go to show that the wireless dealers will themselves *insist* that television transmissions shall be given their rightful place in the regular broadcast programmes.

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Empire Broadcasting.

For some years there has been an intense desire on the part of those holding outposts of Empire to be able to receive broadcasting direct from the Mother Country. Now they will demand to be allowed to *see* as well.

In this connection, our contemporary, the *Wireless World*, in its current issue, calls upon the chief engineer of the B.B.C. to declare a new and more virile policy with regard to short-wave Empire broadcasting. In endorsing this attitude we may point out that other countries, notably Holland and America, commenced short-wave broadcasting long before we did. This has produced two results: (1) those in lonely places depend primarily for their wireless entertainment on foreign stations; (2) other countries are speedily acquiring a more complete knowledge of the behaviour of short waves, and of the design of short-wave transmitters than ourselves.

The significance of short waves in relation to television is apparent from a study of Dr. Robinson's important and timely article appearing in this issue. We must watch very closely any attempts on the part of Governments to relegate television to short waves exclusively until more is known about them.

Communication.

The recent visit to America of the Prime Minister is a reminder of the fact that, in politics, as in business, when matters of extreme importance are at issue between widely-separated interests, there comes a time when negotiations can make no further useful progress until the principals meet in person. These contacts are questions of personality. It is the interaction of facial expression and intonation of voice which renders it possible to put a personality on to the ether by television. As this new form of communication develops the need for transporting our bodies across the world to make contact with personalities will become less and less necessary.

One of the greatest factors in the building of our civilisation has been the speed of communication. Giant strides have been made in recent years in electrical communication, but it is about to progress still further and still more rapidly. Since television is the fastest known means of communication, it is bound to be the most vital link in the world's electrical communication systems of the future.

Co-operation.

Just as nothing worth while can be accomplished without effort, so where there is a will there is a way. The present task of giving Television—so long promised and so long delayed—to the British public, calls for immediate and close co-operation between the radio manufacturers, the Baird Companies and the B.B.C. If that co-operation is not forthcoming, British prestige must give way to foreign enterprise and all that that implies.

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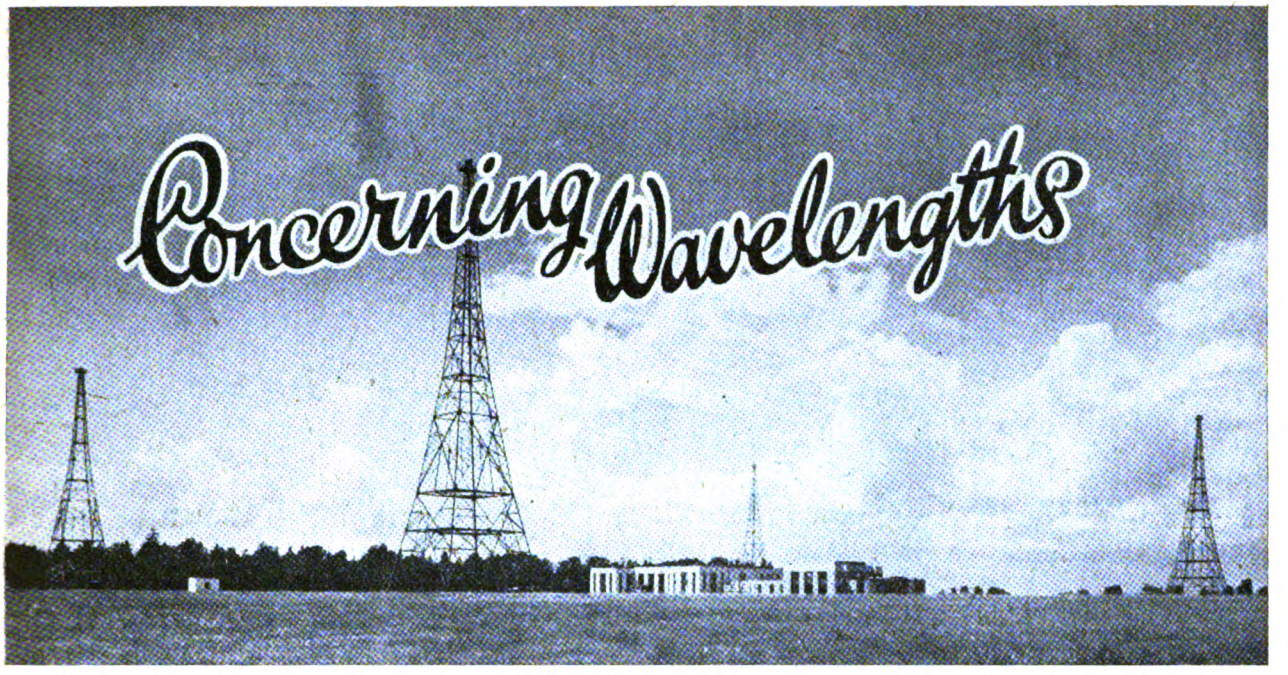

By *J. J. Robinson*, M.B.E., D.Sc., Ph.D., M.I.E.E., F.Inst.P.

AT the present moment there are suggestions coming from various sources that television would find its place in the ether by using short waves. As a subject for serious consideration, television has not yet established itself firmly enough to make the International Radio Conferences allocate special frequency bands solely for its own use. This condition will, however, arise at an early date, for as the months go by the ether is being used for television more and more throughout the whole world.

Correct Views Essential.

It is of vital importance to have the most suitable frequency bands allocated for television purposes, and as there are very many aspects of the subject, it is essential to commence as early as possible to form correct views as to which frequency band, or wavelength band, will be best.

This is a very wide subject and it is not possible to discuss it thoroughly in a short article, but certain features which have a bearing on the subject will be discussed below.

The first consideration is the actual use that is now being made of television, and, further, the uses to which it might reasonably be applied in the future.

Throughout the whole world the chief application at present appears to be in broadcasting, the aim being to bring into the home actual vision of events which are taking place at a distance. As an alternative or reinforcement to television broadcasting, lengths of cinema film will probably be broadcast between television items, just as gramophone records are broadcast to-day between ordinary sound broadcast items. In Germany and in America cinema films are already being broadcast. For experimental purposes they are easier and cheaper to transmit by television than human faces.

The much-talked-of home cinema, receiving films broadcast from a central station, is not likely to come about for obvious economic reasons; it would not pay to make an expensive film which could be seen by everybody at one performance.

Broadcasting of television has such a powerful popular appeal that it has outweighed all other considerations, and the development of television is almost consistently along the broadcasting lines, even though it is recognised that many considerations prevent perfection being obtained, or even from being within sight at present. There are, however, other uses to which television can be applied. For instance, instead of broadcasting in the sense of receiving in one's own home, one might concentrate on the transmission to cinema halls, where more elaborate receiving apparatus could be employed, and where skilled operators could obtain much better results than the average man could possibly obtain on a smaller home instrument.

Commercial Applications.

Another application is for newspapers, where print and picture could be transmitted from one place to another by wire or wireless. This is, of course, being

Our title block shows one of the latest pictures of the new B.B.C. Station at Brookman's Park.

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accomplished at present, although the method is usually called photo-telegraphy, or facsimile telegraphy, and there is no doubt that newspapers will tend more and more to employ this method for obtaining their news and pictures.

In considering the wave-lengths to be employed, we must bear in mind these various applications, particularly that of broadcasting.

We must next consider how any particular wave-length or range of wave-lengths may be obtained for television.

In all countries there is a strict supervision of the ether, and, in fact, there exist monopolies usually under the direct control of the various Governments. Although it is in the interests of the general public that there should be very strict control of the ether, it is undesirable that the sponsors of new developments should be prevented from using it altogether. It is fairly obvious that the older services of telegraphy and telephony have made such great demands that the ether is practically full, and those in control have a very difficult task to find room for the new services of television and photo-telegraphy.

Dr. James J. Robinson, D.Sc.

Usually when a demand is made for facilities to broadcast radio optics, those in control throw back the responsibility by declaring that they are not convinced that there is a public demand for it. They have granted experimental facilities, but actually by the use of the word "experimental" they kill at the very outset any possibility for demonstrating that there is a public demand.

In this country experimental transmission for radio optics has been granted on two occasions, once for photo-telegraphy and once for television; but how can the public be expected to purchase instruments when there is no guarantee that they will have permanent facilities to use them? And how is it possible under such conditions to judge whether there is a public demand?

It is essential to avoid the word "experimental" when radio optical transmission is allowed, and it is further absolutely essential to allow sufficient time for the transmissions, these times being allotted so that the average man can conveniently use them, which he cannot do at midnight or in the middle of the morning. Further, in the case of television, in order to obtain its relative value and therefore its popular appeal, the simultaneous reproduction of speech or singing with the televised image is essential.

Those in control of the ether do not usually look favourably on any request to erect special transmitting stations. For instance, in this country all broadcasting stations are the property of the Government, and any requests for broadcasting facilities, if granted, mean that the existing stations must be used. Here is the trouble. These stations are fully employed in the convenient times on telephony, and a request for television implies a sacrifice of some of the time already allocated for telephony.

As regards the wave-lengths for television it would thus appear as if some advantage might be obtained by using a different wave-length range from that at present allocated to telephony broadcasting, and there is a faint possibility that on the shorter wave-lengths some possible spaces might be found. However, again television is somewhat late, for it is already by no means easy to find free spaces on short wave lengths.

Another aspect for consideration is the nature of television, and we must go into some detail to see whether long or short wireless waves are conducive to the best television results. This is by no means easy, and we really should consider the subject from some different aspects.

A very important aspect is the definition of the image in regard to the length of the waves. At the present moment a usual definition of the television image corresponds with about one thousand picture elements or "*dots*." When the images follow each other at the rate of ten per second, we must deal with ten thousand picture elements per second, which on the continuous scanning method corresponds with modulating frequencies approaching ten thousand per second.

Signalling by wireless waves is generally effected by starting and stopping these waves, or by increasing and decreasing their amplitude. Obviously, if we wish to transmit at the rate of ten thousand signals per second (and this is necessary at present in television) the frequency of the carrier waves cannot be less than ten thousand, for we must have at least one wave to form a signal. In fact, wireless signalling would be

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impossible unless there were more than one wave per signal, and it is advisable to have a train of waves consisting of a considerable number of waves for each signal.

For the present definition of the television image corresponding to 1,000 picture elements, and dealing with about 10,000 picture elements per second, when the wave-length is 300 metres, there are trains of waves available of 100 waves each for each picture element, and this is a reasonable value. For a wave-length of 3,000 metres the trains would only consist of 10 waves, which is getting low, and for a wave-length of 30 metres the trains would contain 1,000 waves. Thus it is obvious that the wave-length places a definite control on the definition of the television image, and as this definition is improved, say to 10,000 picture elements, it will be physically impossible to employ long waves.

Short Waves Apparently Indicated.

Thus again, from quite a different aspect, television seems to have the short wave-lengths indicated in preference to the long wave-lengths.

When we consider the actual properties of short and long wireless waves, we find that the long waves are much more reliable than short waves. It is possible to transmit with long waves over very large distances at any time of the day or night, or at any season of the year. The Rugby transmitter or the Daventry Broadcasting Station (5XX) can certainly both be received within the British Isles at any time, and in the former case, Rugby communication is world wide almost irrespective of season or time of day. Naturally for long waves very large power must be employed, but their use is worth while in order to obtain reliable communication.

Medium wave-lengths, such as the broadcast band from 250 to 550 metres, have different properties, and it is found in this region that the time of day has some influence on range, communication being better at night. However, there is a vast amount of experience of this band of wave-lengths, and for comparatively short distances, 50 to 150 miles, fairly reliable communication is effected.

Short waves, below 100 metres wave-length, have most remarkable properties, which at the same time are most variable. There is considerable difference in the day and night range, and, in fact, it is necessary to change the wave-length during the day in order to guarantee communication between distant places. With very small power it is possible to communicate over thousands of miles with short waves, but the time of day, geographical situation, season of the year, and other factors known and unknown affect the result.

Fading and Skip Effects.

Again, the received signal strength is liable to vary very considerably, sometimes being very strong and sometimes very weak, even to vanishing point, this phenomenon being called "fading." For the shorter waves there is another phenomenon called the "skip" effect, where signals are absent over a considerable region near the transmitter, being received for the first few miles, then vanishing for 100 to 500 miles, then appearing again and being heard up to thousands of miles.

There is therefore much still to be learned about short waves. Of course, they are employed very largely at the present time, and for very long distance communications, but their principal use is for point to point work, which is communication between two fixed points. Under such fixed conditions it is possible in many cases to change the wave-length during the day so as to guarantee communication between the two points for a large part of the day.

Most of our considerations have pointed to short waves as being the most suitable for television purposes, principally those dealing with the nature of television and the need for the best possible definition of the image, and again the fact that the longer waves are nearly all employed for the older services. However, the last consideration of the variability of the short waves, the uncertainty of communication, the fading of the signals, the uncertain influence of fading on the television image, the fact of the skip distance, and the variable range by night and day, all these make us very cautious in accepting short waves as the present medium for television, especially when we consider that the chief application of television at present is to broadcasting.

Medium Wave-lengths Indispensable.

For this purpose, therefore, we must at present insist on the medium wave-lengths in order that we may have the chief virtue of broadcasting, the local influence. Short waves for broadcast purposes might be of use if the people of England were supplied by transmission from Australia and *vice versa*, but although this would be interesting and useful, the local influence must be the controlling factor of broadcasting, and skip distance, day and night effects, and fading are all against any possibility of short wave broadcasting at present.

Again, television is a new subject with many difficulties of its own to overcome, and it should be afforded the advantage of a certain means of communication which has not also its own experimental difficulties.

Thus as broadcasting at present is the principal application of television, *it is essential to employ medium wave-lengths*, leaving the short waves until their properties are much better understood.

CONTRIBUTIONS TO "TELEVISION"

THE Editor invites contributions—interesting articles, sketches and photographs—which will be carefully considered.

While every care will be taken of articles, photographs, drawings, etc., submitted, the Editor and Publishers cannot hold themselves responsible for loss of or damage to such contributions.

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FORWARD!

The Progress *of* Televisio

By *Dr. S. Loewe* a

THOSE interested in television should know at the outset that ideal reception depends much more upon the quality of the receiver itself than is the case with ordinary broadcast reception. For television the most suitable receivers are those which can reproduce without distortion a particularly wide range of frequencies. In the case of the television image distortion becomes still more clearly visible than is the case in the reproduction of music by loud speaker, for the eye is a much more accurate organ than the ear. If, for example, in the receiver the high frequencies are wanting, then the details are wanting in the picture; or, in the case of defective reproduction of the low frequencies, all large surfaces in the picture appear dim and indistinct. It is indeed fortunate that endeavours to improve wireless receivers from the musical standpoint have already led to the solution of the very problems which required to be solved before good transmission and reception of television could be achieved.

Dr. S. Loewe, Chairman of Loewe Radio.

The Television Unit.

In order to reproduce the pictures, only relatively small additional apparatus to the normal wireless receiver is necessary. It consists chiefly of a spirally perforated disc, rotated by an electric motor, and a neon lamp. The brightness of the neon lamp is altered by the transmitter which is modulated in keeping with the object to be transmitted. By the skilful arrangement of the perforations, and the right speed of rotation of the disc, it is ensured that the television object to be transmitted becomes visible in a "picture section."

Now as to the television pictures themselves. It is regrettable that in the daily papers, and to some extent in trade papers, too, quite exaggerated expectations have been disseminated with regard to what television technique to-day permits of presenting. Television technique has already so far advanced that the transmission of heads of one or more persons in a recognisable form can take place. Up to the present it is not possible to transmit scenes such as we are accustomed to see in the film. The images transmitted have too few details for this. It is not, it is true, impossible to reproduce the requisite amount of detail; the limitations result from purely wireless considerations. In order to transmit more details it will probably ultimately be necessary to change from

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n Germany

Dr. Paul Goerz

the present broadcasting waves to short waves, when more is known about them as to overcoming "skip distance," "fading," etc. For the present, at least, the television service must operate on the normal wireless waves (see article by Dr. J. Robinson on page 425).

It may be said, however, that even within these limitations the viewing of televised pictures presents a charm. Some of the readers of TELEVISION may have had an opportunity at the last Wireless Exhibitions in Berlin and London of satisfying themselves personally as to the clearness of the television picture. Those who did not approach the television apparatus with excessive expectations (brought about by misleading articles) will have been highly astonished with the excellence of the picture. In addition, the simultaneous reproduction of picture with speech (or accompanying music) is essential in order to see television in its true perspective. For the present two separate receivers are necessary, one for the speech or music, the other for television. It is possible, however, that the picture and sound will later on be reproduced by one single receiver.

Activities of Fernseh A.G.

The Fernseh A.G. has utilised the weeks following the close of the Berlin Wireless Exhibition for the purpose of developing and testing out a television receiver which is to be placed upon the German market at the end of December.

The apparatus will correspond substantially in design and construction with the models shown at this year's Wireless Exhibition in Berlin, and illustrated in the October issue of TELEVISION.

The Fernseh Company has, however, decided to adopt, in the place of the large and the small models exhibited at the Berlin Radio Show a medium model, to work in conjunction with a mains-operated wireless receiver. The television unit will include a small Universal motor (of special design) for driving the Nipkow disc which will be 400 mm. in diameter with the image lying transversely (*i.e.*, horizontal scanning).

Dr. Paul Goerz, Technical Director of Zeiss Ikon, and Chairman of Fernseh A.G.

The television image will then be magnified by a Zeiss lens.

Of course it is essential that the purchaser has a mains-operated set with a sufficiently large power valve. The company will supply this where necessary.

For the benefit of those who already own a small wireless set—and which is not mains-operated—the company will supply a television receiver into which the power valve may be fitted. The television unit can then be directly coupled up with the wireless receiver.

With respect to television transmissions in Germany, the German General Post Office has already begun (about three weeks ago) regular transmissions twice a day. As the transmissions are confined to the Witzleben transmitting station, the range of reception is, for the present, very restricted owing to the unfavourable radiation from this transmitter.* In order, however, to make the present transmissions more favourable for Berlin receivers, the General Post Office is now engaged in laying a new cable from the Post Office building to the Vox-Haus, whence the ordinary Witzleben wireless programmes are transmitted. Later on it is intended to effect television transmissions through the Zeesen trans-

* Witzleben's power has recently been cut down from 5 kw. to 1½ kw.

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mitter at Königswusterhausen, which, owing to its much greater energy and its better conditions of radiation, can also be heard abroad. For this purpose a special cable will also be run to Zeesen.

So long as television transmissions are sent out only from *one* of the wireless transmitters, a combination of simultaneous sound and television reproduction can hardly be reckoned on for regular transmissions. It is therefore expected that the Post Office will decide to set up a special transmitter for television. All negotiations conducted latterly at the General Post Office suggest that the erection of such a transmitter may be undertaken very shortly.

It must further be mentioned that President Kruckow, the present director of the German Central Post Office, has been appointed Ministerial Director to the Post Office Ministry, and Herr Ohnesorge has been appointed President of the General Post Office. We trust that the new President will concern himself with the further promotion of television through the Federal authorities as was so pre-eminently the prerogative of his predecessor.

A Visit to the *Goerz Works*

By *A Special Correspondent*

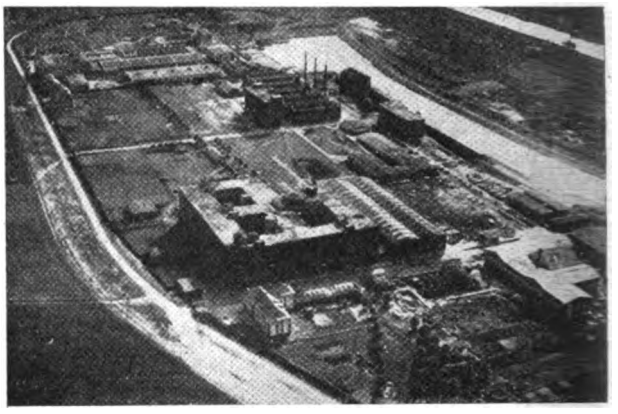
ONE has only to glance at the accompanying bird's-eye view of the Goerz Works (branch of the famous Zeiss Ikon organisation) in order to realise the size of the factory which, with those of the Baird International Television Co., Ltd., the Loewe Radio Co., and the Bosch Co., have united in Germany under the head of Fernseh A.G. for the purpose of handling Baird television interests in that country. In the foreground are seen the actual Goerz Works. These are situated at Zehlendorf, just outside Berlin. In the background are the glass and film works—all part of the Zehlendorf plant.

Dr. Paul Goerz, who is Managing Director of both the Goerz Works and the Fernseh A.G., has a strong personality, and, as may be expected, is an extremely busy man. When I made my request to be shown through his works, however, he courteously offered his services as guide, an offer which I promptly accepted.

To attempt to go into the details of this vast business would fill many pages, so I must confine myself to generalities. Over 2,500 people are actively employed. The Zeiss Company is known throughout the world for its peerless lenses, but it was astonishing to find that many other commodities are produced by the same organisation under the same roof.

Variety of Products.

As we passed through the shops I made my acquaintance with ingenious adding machines, boasting a veritable maze of intricate mechanism all relying on electric drive for their operation. Next we came to safety locks, and found both male and female employees attending to as many as six and four automatic machines respectively, just as if such were mere child's play. As most of these machines are turned out at the Goerz Works, it will be gathered how self-contained they are.



An aerial view of the Goerz Works at Berlin-Zehlendorf.

To see the many processes through which the various types of glass reflectors pass was an education in works efficiency. An endless conveyor brought the "*raw shade*" from the store in which it had been deposited after leaving the glass factory. From thence it passed through a great many processes before emerging as the finished product. These included polishing, cleaning, silvering, galvanic baths, aluminium covering, drying, cooling, etc. The silvering tower seemed a most efficient piece of apparatus, the mixing of the mercury silver solution taking place on the upper floor, whilst the reflectors were treated as they passed up the tower and down again, transported on a continuously moving framework.

What, to my mind, constituted the most striking example of organisation and departmental management was the department devoted to the assembling of box cameras. This particular box camera, made on mass production lines, forms one of the specialities of the Goerz Works, and one could not help but marvel

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at the way girls and women performed their allotted tasks with nimble fingers and no loss of time. First we met the metal case stamping, saw it sprayed "matt" and bright black, the leatherette covering glued on, shutters assembled and mounted in place, and the lenses fixed.

Two endless bands passing from one end of the shop to the other, with an intermediate junction here and there, served to pass the product from worker to worker until eventually it emerged at the test bench there to undergo routine pass tests before going into stock. It all looked so simple, and yet one realised that it represented the culmination of years of experiment, even down to the exact speed of the conveyor. From start to finish the time taken to make a camera was exactly *seventy minutes*. The popularity of the product can be gauged from the sales which run into hundreds of thousands a month. The accompanying photograph gives some idea of this section of the plant.

All kinds of scientific instruments come within the scope of the Goerz Works organisation: barographs, telescopes, polarisation apparatus, thermographs, refractometers, etc.

Every consideration is meted out to individual employees, whose working hours are from 8 a.m. to 4.20 p.m., with a twenty-minute break for a mid-day meal. The works has its own railway for goods

View of the box camera assembly shop. Note the endless travelling band.

traffic and the conveyance of employees to tram and 'bus termini. Everywhere one was struck with the efficiency habitually associated with German enterprise. My expression of thanks to Dr. Goerz for his painstaking explanation of the various processes employed, and for his gracious answers to my many questions, seemed but a poor return for one of the most interesting experiences I have had.

"Wireless Pictures and Television"

UNTIL its inaccuracy was exposed by Dr. J. Robinson in TELEVISION, the dot theory of transmission, as applied to television, was regarded as a serious obstacle to its accomplishments. How firm a hold this habit of considering all forms of picture or image transmission by electricity from a dot point of view had over those engaged in picture telegraphy is revealed, quite unconsciously, by T. Thorne Baker in his book *Wireless Pictures and Television* (Constable, 6s.).

The earliest experimenters based all their efforts on a consideration of a picture as a number of points or elemental areas to be sent separately and in proper order to a receiving instrument which would reconstruct them into a crude likeness of the original. Later investigators without exception followed this dot idea of picture building. In this they were to a large extent justified by virtue of the almost universal use of the half-tone method of reproducing photographs for printing purposes—the finest example there is of the dot method—although, as Mr. Thorne Baker carefully points out, when one comes to analyse such a picture the dots are found to be not true dots, but irregular areas depending for their form on the detail they represent. Thus in the example given in the book, while the dots in the lighter portions of the picture are true points, as the shading becomes deeper the dots grow into six-sided figures, and finally join to give a solid black, while in one portion of the reproduction, where a number of parallel lines are shown, the dots are elongated ovals. Even with this clear indication that dots are not necessarily distinct, clearly formed circular points, the author continues to deal with all pictures from a dot point of view, even when describing later systems in which the picture is built up by strips of varying width!

Apart from this curious little kink, the subject of telephotography is fully dealt with in simple non-technical language. Synchronising always formed a serious difficulty, and the descriptions of the various methods employed, quite apart from their interest as examples of ingenuity, form a useful guide as to what methods are likely to be of use for similar purposes.

Although a hundred and sixty-six pages of the book are devoted to telephotography, a brief eighteen only suffice to give a history of attempts to achieve television, and of these more than half are concerned with a description of a cathode ray method which so far has not been tried out. Systems in common use are scarcely mentioned, and in this respect, therefore, the book is disappointing. Telephotography undoubtedly was hedged about with many difficulties, but the difficulties in the way of television were even greater.

W. C. F.

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Experimental Television Apparatus

By *A. A. Waters**

PART VI

HAVING now described in these articles the design and construction of scanning discs, a suitable amplifier for the reception of television signals, and an adjustable holder for the neon tube, the reader who has constructed or obtained these articles will find himself almost in a position to receive the morning transmissions which have commenced from 2LO.

It will, of course, be essential for the experimenter to construct a scanning disc in accordance with data given by the Baird laboratories, which it is hoped will very soon be available.

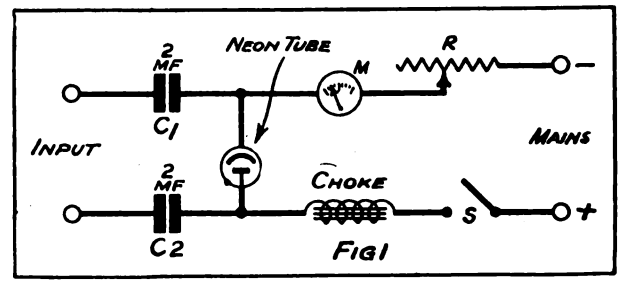
There is, however, still one important link in the receiving chain with which I have not dealt, namely, a suitable unit for providing a striking or sensitising voltage for the neon tube. It is generally considered necessary that this tube shall be operated at a steady voltage somewhat above its striking voltage, the television signals being superimposed upon the faint glow thus produced. A little consideration should readily show the reason for doing this. The received television signals, after amplification, will take the form of alternating voltages similar to those which are applied to the loud-speaker in ordinary broadcast reception. If these voltages are applied directly to the neon tube, without any superimposed direct current voltage, the tube will not glow at all unless the signal voltage exceeds the striking voltage of the tube. This striking voltage may be in the order of 160–180 volts, and hence the weaker portions of the signal will produce no glow, and much definition will be lost, if any results at all can be obtained.

Operating Characteristics of Neon.

Consider now, however, what will take place if the neon tube already has a steady voltage across its terminals slightly above its striking voltage. There will be a steady glow within the tube, and this will be either augmented or decreased by the alternating signal voltage, according to the polarity of this voltage at any instant. Thus the neon glow will vary in proportion to the amplitude of the received signal, which is the necessary condition for satisfactory television reception. Obviously the superimposed steady voltage must be such that at no time will the neon tube be completely extinguished by the television signals, as this would produce dark gaps in the received image, or else would cause an unpleasant over-accentuation of light and shade rather suggestive of shadowgraphs or silhouettes. The value of steady voltage required across the tube is given approximately by the following expression :—

Voltage required = Extinguishing voltage of tube + Half the maximum amplitude of the superimposed signal.

Thus we see that the correct voltage will depend upon the signal strength which we have available, and should, therefore, be made variable in experimental work. In practice it will be found that a fairly fine adjustment is required, as this factor is quite a critical one in obtaining a lifelike image in which the half-tones are well reproduced.



Circuit diagram of the Filter.

In deciding on a source of direct current for the purposes just described, the experimenter must remember that his neon tube may take a current of from 5 to 30 milliamps., and hence small, dry batteries are quite unsuitable for this work. Large capacity dry batteries might be employed, but will be found to be a very expensive proposition when such comparatively heavy currents are required. H.T. accumulators are, of course, quite suitable for the purpose if available, but represent a considerable initial expense.

Undoubtedly far the most satisfactory method is to make use of the house supply mains, when such exist. A minimum voltage of 200 volts will suffice,

* The writer wishes to acknowledge with thanks the assistance given him in the writing of this article by E. L. Gardiner, B.Sc.

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although 250 volts is a more desirable figure, and this can be obtained directly from direct-current mains, or alternatively from the output of any good A.C. battery eliminator. Additional smoothing will not usually be required in either case when the filter unit described in this article is employed, but any necessity for it will be disclosed at once by the following simple experiment. The receiving apparatus having been set up, it is only necessary to strike the neon from the source of current under test, and to observe the resulting glow through any scanning disc, rotating at almost any speed. The existence of any residual ripple from the mains of sufficient intensity to affect the final image will become apparent in the form of a characteristic pattern of dark, wavy or zig-zag lines, which move up or down across the field of view. If no such lines are observed, or if they are negligibly faint, then the use of additional smoothing circuits is unnecessary.

The primary purpose of the filter now to be described, however, is not that of removing mains ripple, and its use is essential whatever source of current is applied. Clearly the striking voltage cannot be obtained directly by connecting a battery or mains eliminator across the neon tube, as this would have the effect of short-circuiting the signal voltages, and some means must be found to prevent this trouble.

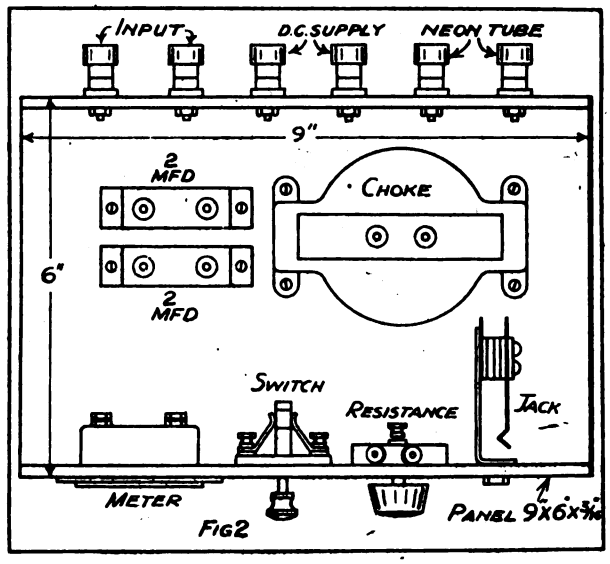
A glance at the circuit diagram of the filter (Fig. 1) will show how this can be effected. The striking voltage, obtained from any suitable source, is applied to the potential divider, R, from which a voltage of the critical value required is applied to the neon tube through the iron-cored choke. This choke serves the double purpose of preventing the signal voltages from being partially short-circuited through the supply, and at the same time forms a sufficient smoothing inductance for ordinary purposes. It should have a high inductance, preferably of over 30 henries, must be capable of carrying 25 or 30 milliamps without undue loss of inductance, and should not have too high a resistance unless ample voltage is available from the supply to compensate for the voltage drop across it.

A wire-wound resistance could be used in place of this choke if a supply of 400 or 500 volts is available, and might result in a slight improvement in the quality of reproduction. It would have to be of low self-capacity however, and of a resistance well in excess of the output impedance of the amplifier employed, hence its use can only be recommended to the advanced experimenter who is aiming at superlative results, without much regard to cost.

The output from the receiving amplifier is applied to the neon tube through two condensers, C_1 and C_2. These can be of $2\,\mu F$ capacity, although the use of $4\,\mu F$ or even $6\,\mu F$ condensers can be recommended if such are available. It is important however that they are of first-class quality, since they will be subjected to considerable instantaneous voltages which may exceed double the high-tension voltage used on the power valve of the amplifier.

A cheap bypass condenser may be expected to break down under these conditions, and the use of the more expensive article built for such work will generally be found to be a sound investment in the long run. As an example, the Dubilier type B.D. condenser represents about the minimum for reliability in this position, whilst the type L.A.C. condenser of the same make would be advisable if funds permit. The use of these condensers is necessary to prevent the striking voltage from being partially short-circuited by the secondary of the output transformer of the amplifier. In the event of the amplifier being already fitted with a choke output filter, they could be dispensed with. The above remarks would apply equally, however, to the choke output condenser, which should be of irreproachable quality.

A list of components required for the filter will be found at the end of this article. There are several ways of incorporating these components into a neat



Layout of the Filter.

little unit that can be attached to the output of a suitable amplifier. I would suggest that a metal box, about six inches square, be used. The screening of these components will help to keep the receiver from becoming unstable. For experimental purposes the method adopted is shown in Fig. 2. A baseboard, ebonite panel and terminal strip are mounted in the usual manner.

The milliameter reads the D.C. current flowing through the neon tube, and it is important that this meter should be used, otherwise the life of the neon tube may be very short. The makers of the Raytheon Tube specify a maximum working current of 20 milliamps, and we have found, at the cost of two tubes, that this current should not be exceeded. The variable resistance should be of the heavy duty type, wire wound. The Truvolt has proved invaluable in this particular unit.

In the next article I hope to tell my readers about the reception of the Baird transmissions.

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Seeing London in Bradford

Splendid Results as 2LO Broadcasts are Picked Up

A FULL report of the accomplishment, as it appeared in the *Bradford Telegraph and Argus* under date October 8th, is given below:

"History was made in Bradford to-day. Television transmissions from London were received in Bradford.

In simpler language, a man, easily recognisable, was seen to be making grimaces and turning his head despite the fact that the man was in London and the witnesses in Bradford.

A *Telegraph and Argus* reporter was privileged to-day to witness this, the first wireless transmission of television to be received in the provinces from the B.B.C. London station.

Mr. H. J. Barton Chapple, who is now associated with the Baird Television Development Co., Ltd., and who was formerly a master at the Bradford Technical College, was in charge of the experiment, and was assisted by Mr. Sidney R. Wright, of Christopher Pratt and Son, Ltd., Bradford, at whose home at Nab Wood the experiment was conducted.

The first difficulty was in securing the London transmission at loud-speaker strength—wireless enthusiasts will appreciate this. This part of the task was in the hands of Mr. Wright, who succeeded with the aid of a screened grid four-valve set in securing sufficient strength.

This valve was coupled with another three-valve amplifier which carried the output to the portable televisor, which was manipulated by Mr. Chapple.

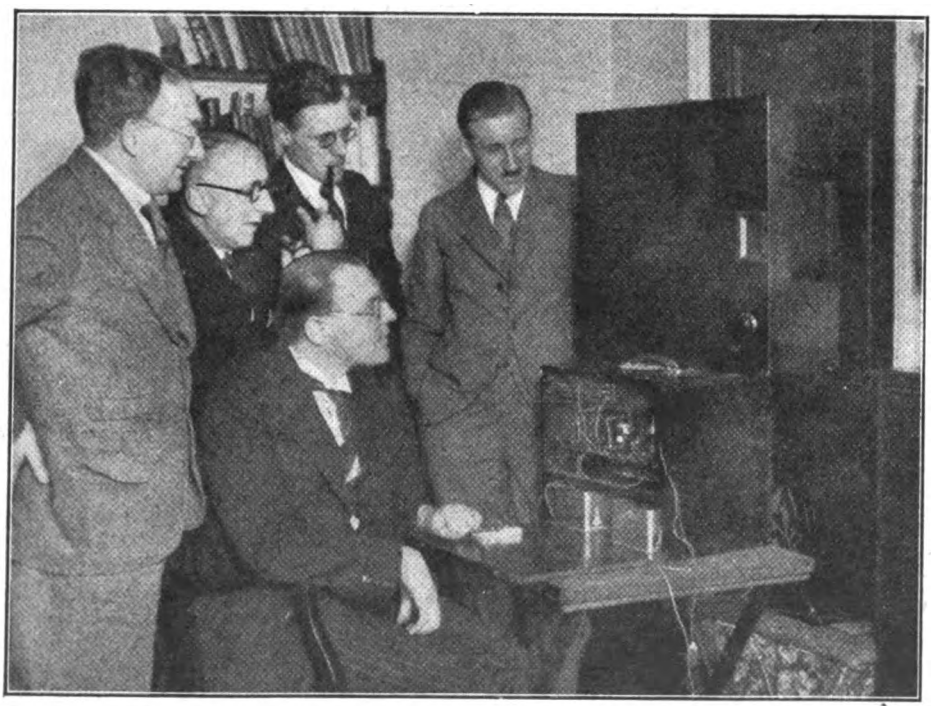
At 11 o'clock the announcement was made that the television transmission was to commence. The loud-speaker was switched off and the televisor switched on.

Through an aperture measuring, roughly, four inches by two—it can, of course, be enlarged to suit requirements—dots of orange light appeared. Quickly the dots flashed past the eye until nothing but a square of orange light was to be seen.

An adjustment here, and then the dots formed themselves into the shape of a man's face. Another adjustment and then the face became recognisable.

Enthralled, the three or four people in the room watched this individual as he turned his head first to one side and then the other, opened his mouth, raised his eye-brows, laughed and scowled. It was difficult to imagine that this vision was being flashed 200 miles through the air. The man disappeared.

In its place there came another vision. Still a man's face, which in a moment was easily recognisable as a profile of the Prince of Wales. He was without a hat, and his collar and tie were easily seen.



Bradford looks in at London.

In Full Daylight.

Listeners who know the difficulty in getting the London transmission will realise that a distinct triumph was secured in attaining such excellent results, and it is evident now that television has reached such a stage as to be of great entertainment value.

It should also be added that the transmission and reception was in full daylight.

Television is still in its earlier stages. Its promoters themselves would be the last to claim perfection for it in the present state, even though a portable transmitter is to be marketed at the remarkably low price

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of £12 12s. The future, however, is remarkably bright and promising.

A year or so, and we shall be able to tune in a talking film, a silent film, a play, an opera, a news event. The happenings will be recorded on the screen and the sound emanating from the loud-speaker."

A further report from the *Yorkshire Observer* for October 9th follows:

RADIO'S MAGIC REVEALED

LISTENING TO LIGHTS AND SEEING SOUNDS

"Invisible rays of light, secret burglar alarms, lights that could be heard, sounds that could be seen. These apparently impossible things were actually demonstrated in Bradford last night at a meeting which at times resembled a scene in a magician's laboratory. In reality it was a demonstration given by Mr. H. J. Barton Chapple, now associated with the Baird Television Development Company, Ltd., to the members of the Bradford Wireless Society.

Although the lecture was primarily devoted to the advance of television, Mr. Chapple took the opportunity of demonstrating noctovision, a discovery which enables fog to be penetrated, thus possessing great maritime possibilities. It has another important use, and that is of constituting itself a burglar alarm. A ray of light, invisible to the human eye, is thrown across a space. Anything passing between the projector and the receiver immediately causes an alarm to ring.

By means of selenium and neon lamps, Mr. Chapple illustrated how it is possible to see sounds, a neon lamp flickering every time the demonstrator spoke. Following this it was shown how by means of selenium light could be made audible on a loud-speaker. These demonstrations led up to an actual demonstration of the television sets.

It was earlier in the day that Mr. Chapple, assisted by Mr. S. R. Wright, of Christopher Pratt and Sons, Ltd., Bradford, succeeded in successfully receiving a television transmission from the London broadcasting station. A *Yorkshire Observer* reporter was able to sit in a room at Nab Wood and see through the televisor the movements of a man in the London studio, and later a picture of the profile of the Prince of Wales.

This was the first occasion on which television, as transmitted by the B.B.C., has been received outside London. The signals were first received on a four-valve screened grid set, passed on to a three-valve amplifier, and thence to the actual televisor."

The stand of Television Press, Ltd., at the National Radio Exhibition, Olympia.

EDITOR'S NOTE.—Due to the large number of letters we have received on the subject, it is hoped that similar receiving apparatus will be made available to those giving lectures on television within the range of the B.B.C. broadcasts.

TELEVISION RECEIVED IN THANET

Extract from
Broadstairs and St. Peter's Advertiser and Echo
Dated October 4th, 1929

"The television programmes broadcast by the Television Studio, Long Acre, London, have been picked up by Mr. F. H. Austen, of 52, Church Street, St. Peter's.

On Monday, September 30th, when the programmes first began to be broadcast, Mr. Austen failed to secure results, but on Tuesday he was able to obtain complete success.

Yesterday, when the next programme was broadcast, an *Advertiser and Echo* representative was present, and Mr. Austen was again entirely successful. As far as he is aware, he is the first enthusiast in Thanet to obtain television results, but if anyone else has also met with success he will welcome the opportunity of hearing from them and comparing notes.

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What the *Advertiser and Echo* representative saw was a moving band of red light, interspersed with circular bands of black, which, it was explained, were music waves visually produced. When these ceased the head and shoulders of a music-hall comedian appeared, and thereafter all facial expression and movements were clearly seen until the end of the turn.

The exhibition was marvellously clear and convincing, and Mr. Austen is to be congratulated upon the skilful pioneer work he has accomplished so successfully."

RADIO DRAMA A STRAIN

WHEN TELEVISION COMES TO THE RESCUE

ERIC DUNSTAN (*late of the B.B.C.*)

From *The Star*, October 17th, 1929:

"Had I not been *The Star's* wireless critic I confess I should not have listened to 'Captain Brassbound's conversion' broadcast last night, but only because I personally find the strain of concentrating on broadcast drama greater than the entertainment which I derive from it justifies.

If one could talk a little during the play (as one can and often does *sotto voce* at the theatre to one's neighbour without creating a disturbance or taking one's whole attention from the stage) it would help; but the trouble with a loud-speaker is that it is impossible against it, or if it is just talking at a comfortable volume the least interruption by conversation entirely breaks the thread of its remarks.

You must have noticed how occasionally people interjecting remarks such as "What was the name of that place?" into the reading of the news nearly always results in the next item being lost.

Yet, if one were listening to the announcer reading the news in the flesh, the assistance of one's eyes to one's ears would enable one, in spite of interruptions, to keep the thread of his remarks. And so with broadcast drama. Until we get television perfected I think its appeal will be limited, because of the concentration needed to follow it in all its detail.

However, I did listen; I was by myself, and I enjoyed the whole performance. Unlike several of the plays we have recently had, there were no 'effects,' and I think Mr. Howard Rose, the producer, made a very wise decision when he realised that Mr. Shaw's own stage directions would convey more to us, a blind audience, than any attempt at descriptive noises.

The play is the usual Shaw framework for biting comments on English institutions, with a good story, and one or two real characters and several artificial and rather unreal ones.

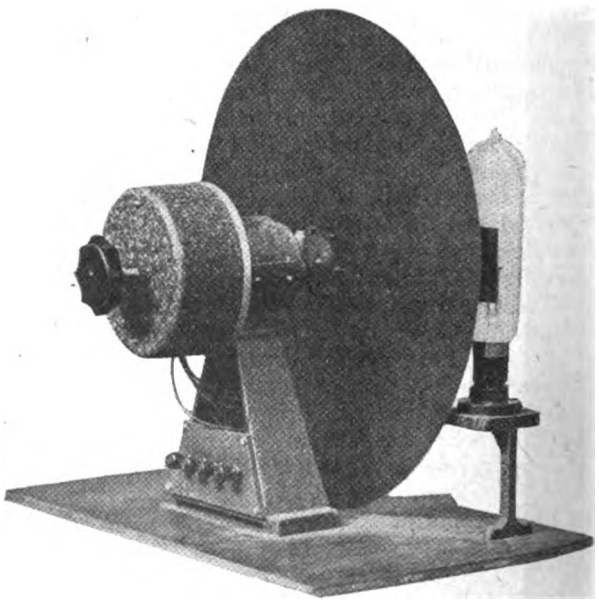
I remember seeing it at the Little Theatre many years ago—I believe it was during an air raid—and I had almost forgotten it and everyone in it, except Miss Gertrude Kingston as Lady Cicely. The same number of years hence I think the result will be the same. Her performance stood out most vividly, and she made the almost incredible Lady Cicely a very real person who could and did convert anybody and everybody.

The others who, to me, became most real were J. Hubert Leslie as Rankin, Neil Curtis as Redbrook, and Charles Farrell as Kearney, the American naval captain. But everyone was good, and I feel sure that those who had the tenacity to listen for the two whole hours must have enjoyed it. Those who had not, I recommend not to miss it when it is broadcast with television, as it will be, I feel sure, not so long hence."

ON GOING TO PRESS.

On enquiry at the Baird Companies' Headquarters at 133, Long Acre, we understand that the Baird Television Development Company are now prepared to license manufacturers to incorporate the Baird Televisor Receiver Unit with suitable wireless receivers.

They point out, however, that the Baird Televisor Receiver Unit is a very specialised product, requiring the finest precision machinery for its manufacture.



The Baird televisor receiver unit (removed from its case) as shown at the National Radio Exhibition at Olympia recently.

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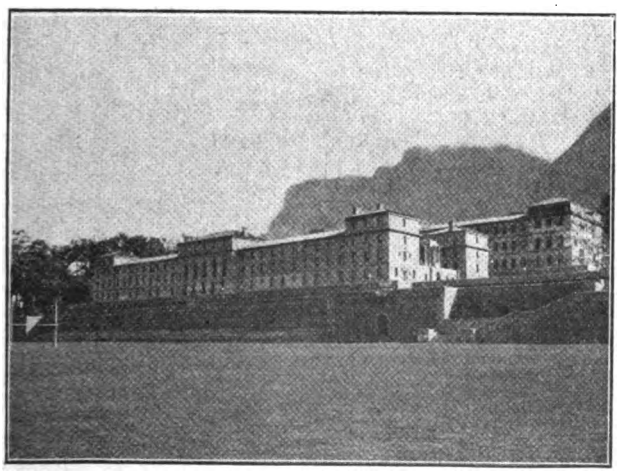
Television in South Africa

By *Clarence Tierney*, D.Sc.

Dr. Tierney.

THE annual meeting of the British Association for the Advancement of Science was held this year in South Africa from July 22nd to August 5th, under the presidency of Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S. In his presidential address Sir Thomas dealt with the "International Relationship of Minerals," in which he developed the theory that those nations which controlled the production and supply of such essential minerals as iron, copper and coal controlled also the determining factor in time of war. Agriculture, he observed, was of greater monetary value to our colonies at the present time than their developed mineral resources, but he drew attention at some length to the significant fact that with the English-speaking nations, including America, must reside the balance of power in peace or war, since they controlled by far the greatest production of those essential minerals without which no war could be long maintained. It would appear, therefore, that with these nations rested the responsibility of enforcing the observance of the Multilateral Pact for the renunciation of war by refusing supplies to any nation proved guilty of non-observance.



New University building, Cape Town, where the principal meetings of the British Association were held.

The meeting was characterised by many notable features, not least of which were the demonstrations of practical television given at Cape Town and Johannesburg at the invitation of the South African Association for the Advancement of Science. The apparatus, kindly lent by the Baird Television Company, was sent out from England in the care of Lord Angus Kennedy, a vice-president of the Television Society, and two assistant engineers.

In spite of the fact that the instruments were badly damaged in transit, it is worthy of note that these were effectively repaired, assembled and ready for practical demonstration within four days of their arrival at Cape Town, a fact which reflects great credit upon the demonstrators, and which so impressed one of the earliest visitors that, in inscribing his name in the visitors' book, he added that the things which impressed him most were the fidelity of the received image, the simplicity of the instruments, and the honesty with which these had been exhibited. This image is familiar to many of our readers in England and need not be referred to at any length in this report, but mention might very properly be made of the impressions made upon the very large number of important persons who attended the demonstrations and witnessed for themselves the notable developments which have been achieved in the apparatus and the excellent results obtained.

These impressions are most adequately expressed in the remarks appended to the many signatures added to the visitors' book, all of which are unanimous

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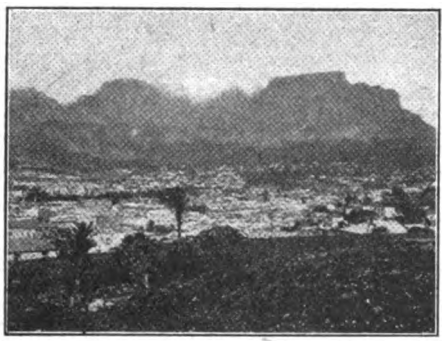
in their expressions of amazement and satisfaction at the remarkable development already attained and its assured future and application. It is not possible nor proper here to mention the names of the many independent, competent and scientific authorities who witnessed these demonstrations, all of whom expressed the view that the science has reached an advancement far beyond what they had been led to suppose by the statements of prejudiced and vested opponents in our own country. Such observations as "amazing," "far exceeding our expectation," "marvellous," "wonderful," etc., are too many to enumerate. It is sufficient to say that an honest anticipation prevails for facilities and a public service for television within the Union.



Cape Town, showing Table Mountain in the distance.

The demonstrations, which were the first ever witnessed in Africa, were given in the University buildings at Cape Town and at Johannesburg, and, in addition to the visits of the men of scientific eminence already referred to, were also attended by several Cabinet Ministers, Senators, and other responsible administrative authorities, in addition to a very large number of both local and visiting members. The type of receiver used was the dual instrument, televisor and loud-speaker, similar to that lent for demonstration purposes to the Television Society, and the transmitter was of the type used by Baird at recent demonstrations in London and elsewhere, and in spite of the difficulties inherent in the transport of delicate instruments thousands of miles over land and sea, and the damage these sustained in transit, the demonstrations were an unqualified success, the results of which are reflected in the enthusiastic and encouraging interest shown by both scientific and administrative authorities alike.

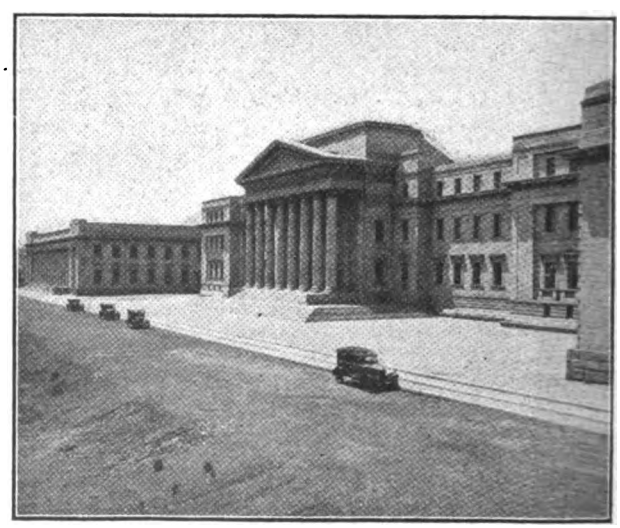
Seeing is Believing.

The pleasure and amazement of a party of distinguished visitors witnessing for the first time the incorporation of television and loud-speaker telephony, and observing the perfectly reproduced image of an important personality who accompanied them, and hearing from him an address at a distance, was not only impressive but convincing of their satisfaction and approval, and the re-orientation of the conclusions they had hitherto formed from opinions loudly expressed by a small but pedantic coterie who, without adequate knowledge of the invention, presume to condemn it, while they have never so much as witnessed a single demonstration.

During his extended tour of many thousands of miles through that vast and uncharted continent the writer had abundant opportunities for judging the incalculable value of this new means of communication as a bond of fellowship with the Homeland. Those in England have little or no idea of the ecstasy and inspiration to our absent friends abroad of the sound of Big Ben, or of the patriotic pride with which they listen for those chimes on their wireless sets. Such a sound in the heart of the Colonial settler, whether in an African city or in the loneliness of the high veldt or bush thousands of miles away, is as much the embodiment of the bonds of Empire, of which he is still proud to be a citizen and a pioneer, as is the Union Jack itself.

Why cannot he also see it? Our great public men often address the wide world through our own Empire Broadcasting Station. Why cannot they also be seen? They could if only our administrators were as fully alive to the potential value and influence for good to trade, to industry and to the Empire itself in the scientific development and application of television, as they appear to be in debating the taxable value of women's stockings or spending months of valuable time and enormous sums of money in affording so-called safeguarding to some of our inefficient, decadent and extinct industries.

In conclusion, mention might be made of the fact that at the invitation of the broadcasting authorities the writer gave an evening talk from the Cape Town studio on "Television: its History, Development and Application," which aroused considerable interest amongst listeners, with the result that it is suggested that a South African branch of the Television Society should be formed for the benefit of those interested in the subject, and in order that they might be afforded facilities for further study of this new and important art, in addition to obtaining first-hand authoritative information upon current developments. We wish all success to this proposal, and extend our cordial greetings and good wishes to the organisers and members of this promising group.



University buildings, Johannesburg, where some of the meetings were held.

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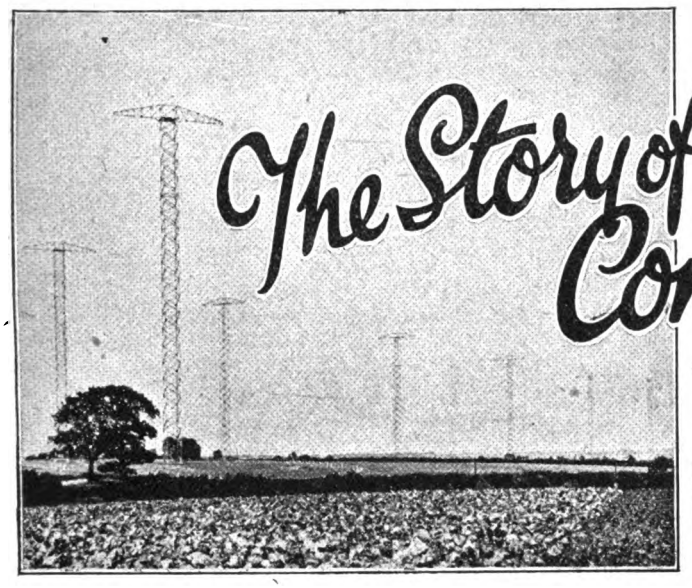


The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

PART XI.

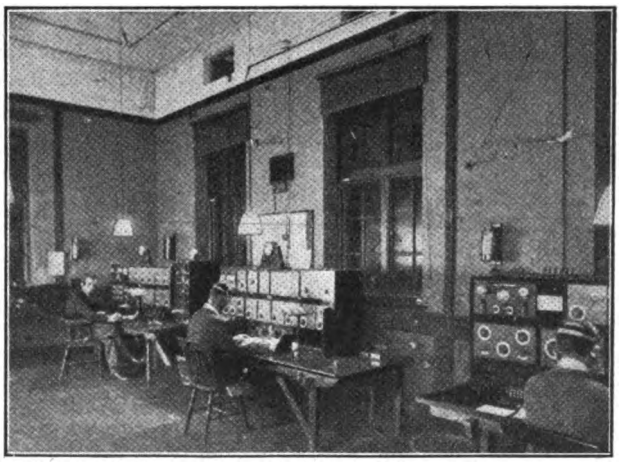
SHIPS' COMMERCIAL COMMUNICATIONS

THE communications of ships as affecting the safety of life at sea were considered in the last article, but the great bulk of communication consists of what is called "commercial traffic," that is to say, ordinary messages between people in ships and people on shore.

In this country, as in other countries in Europe, communication with merchant ships is organised as an extension of the telegraphic communication of the country, and is controlled by the same Government department; with us, the Post Office. In North America, wireless communication with ships is, like the inland telegraphs, controlled by commercial companies. All governments which control these stations subscribe to the regulations as regards tariffs, procedure, etc., which are embodied in an International Radio-Telegraph Convention, and though the Governments of the United States and Canada are not tied by these particular regulations, no difficulties arise in practice as the operating companies observe the rules laid down. The present International Convention came into force on January 1st, 1929, and was the outcome of an international conference held at Washington in 1927. This was the largest and most important gathering of wireless experts ever held. It was attended by 346 representatives from 79 countries, and, surprising as it may appear from its size, it produced first-class results.

Portishead Radio.

The principal station for conducting traffic with ships in this country is the Post Office station known as Portishead Radio. It consists really of two stations, the operating station at Burnham-on-Sea and the transmitting station at Portishead. The messages *from* ships are received at Burnham and telegraphed by direct land line to the Central Telegraph Office at the General Post Office in London, from which they are telegraphed to their destination. The messages *for* ships are telegraphed to Burnham, where the operators work, by means of land lines, the wireless transmitters at Portishead, so that, though the actual signalling is done at Burnham, the wireless waves are emitted from Portishead. This is called working by distant control, the object being that, by separating the stations, messages *to* ships can be keyed at the operating station, and emitted on certain waves from the transmitting station at the same time as messages *from* ships are being received on other waves at the operating station. In other words, duplex working is



Some of the receiving sets at Burnham Wireless Station.

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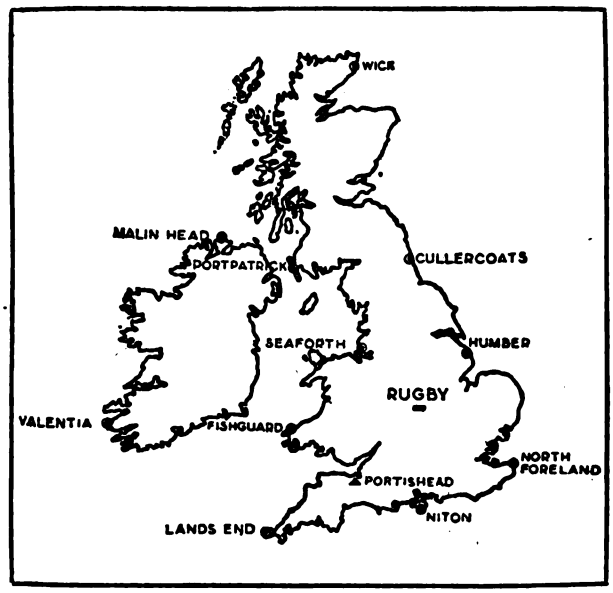
attained, and all important land wireless stations are now arranged in this manner.

Portishead Radio communicates with ships on the continuous wave system only, and at present the bulk



Map of the stations in the United Kingdom and Irish Free State which are used for ships' communications.

of the traffic is passed in both directions on wavelengths between 2,000 and 2,4000 metres, but during the last two years, short-wave sets have also been used both for transmission and reception. The total annual traffic now approximates to a million and a half words, and the rate charged is 11*d.* a word. Of this, 6*d.* is credited to the station, 4*d.* to the ship, and 1*d.* to the inland telegraphs. The range of working on the long waves is notified as 2,000 miles, but under good conditions greater ranges are frequently obtained.

On the short waves much greater ranges are obtained; in fact, world-wide communication is often possible. Short-wave sets in ships are still in the experimental stage, and only about 150 ships of all countries are notified as being capable of communicating with Portishead on short waves, whereas about 500 ships are notified for long-wave communication. Long-wave sets have been in use for many years, the problems are solved and the communication is stable, but there can be little doubt that short-wave working with ships will come to its own in due course, as it has already done in the case of long range point-to-point communication.

All these communications with ships are carried out by hand keying, and telephone reception. Automatic working is sometimes used on the other side of the Atlantic. It has been tried here, and is, of course, quite practicable, but with the present volumn of traffic per ship it is not yet an economical proposition.

Rugby Radio.

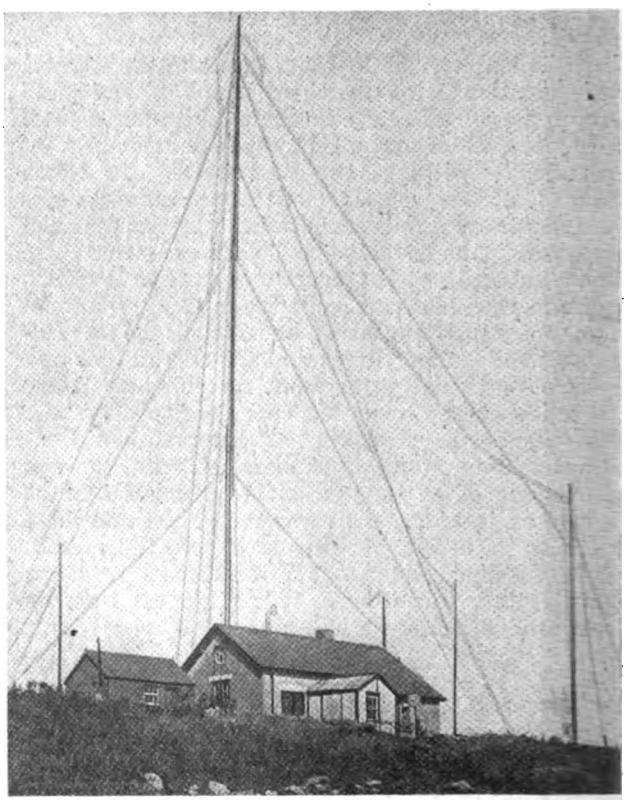
Messages can also be sent to ships in any part of the world from the Post Office high-power station at Rugby, but ships cannot reply direct, though they can, of course, do so by other routes, *e.g.*, through Portishead if within range, or through foreign stations and thence by telegraph and cable. A charge of 1*s.* 6*d.* a word, including 4*d.* for the ship charge, and 1*d.* for the inland telegraph, is made for these broadcasts to ships, and at present about 3,000 ships are capable of receiving the long wave used by the Rugby station.

Press messages are also broadcast from Rugby Radio to ships all over the world at definite times every day.

Wireless messages for ships, in plain language or in code, can be handed in at any postal telegraph office in the country. The name of the station must be specified in the address of messages via Rugby or stations abroad, and in the case of messages at reduced rates for short voyage ships. In all other cases, however, where the sender is not sure of the appropriate station, he need only insert the word "wireless" on the message form in place of the station's name, and the Post Office will do the rest by routing the message through whatever station is most suitable in the circumstances.

The Coast Stations.

The Portishead station carries the bulk of the traffic to and from large passenger ships as all these are now fitted with continuous wave sets, and this traffic is nearly half the total of our whole ship and shore traffic. The remaining traffic is for the most part with smaller ships, and this is conducted through the



The Coast Station at Fishguard.

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Post Office coast stations. These stations, as we have already seen, are also used for distress purposes, and are distributed round our coasts so that no ship near the coast can be out of wireless touch with one or more of them, in fact the necessity of catering for this distress work is the only real justification for incurring the expense entailed in working some of these stations.

Exit Spark Transmitters.

The great majority of the smaller ships are fitted with spark installations, the remainder with interrupted continuous wave sets. The stations, too, used spark sets until recently, but I.C.W. sets are now in use in some of them, and will shortly be in use at all of them, as it is laid down by the Washington Convention that no coast stations can use spark transmission after 1934. This regulation was made in the interest of broadcast listeners, as spark transmission interferes seriously with the reception of broadcast programmes in the vicinity of the station. For the same reason, no new spark sets must be fitted in ships after this year, with the exception of very small installations, below 300 watts.

The coast stations are situated at Wick, Cullercoats, the Humber, North Foreland, Niton, Lands End, Fishguard, Seaforth, Port Patrick, and Valentia and Malin Head in the Irish Free State. The ranges of the stations are notified as 250 to 300 miles, but much greater distances are frequently obtained.

Commercial Rates.

There are about 3,500 British ships fitted with wireless, but the stations communicate, of course, with ships of all nationalities. The rates are the same as for Portishead, viz., 11*d.* a word, except in the case of short voyage ships, where reduced rates of 3½*d.* or 5½*d.* are charged according to the service on which the ship is engaged. A press service with ships at half rates is also available.

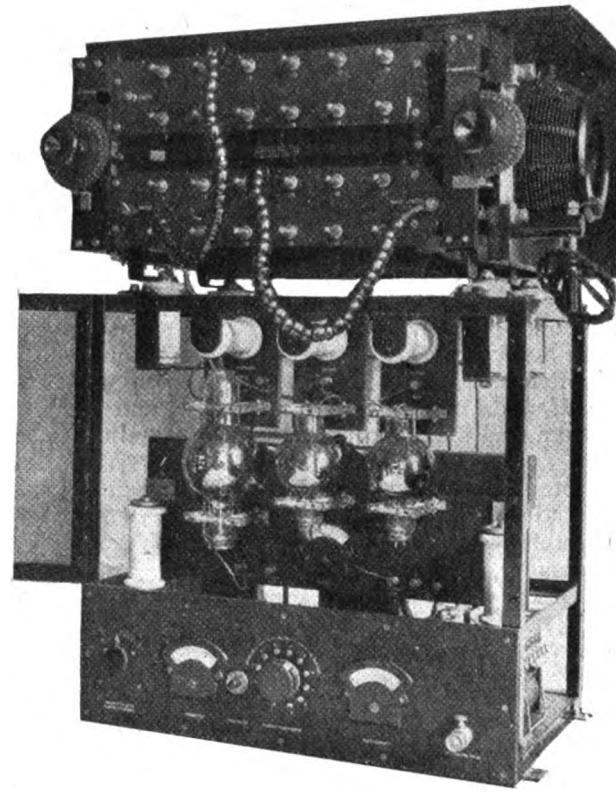
It is laid down internationally that, for distress purposes, ships must normally listen-in on the 600 metre wave, and the stations also keep watch on that wave. All calling is therefore carried out on the 600 metre wave. Ships send their traffic also as a rule on this wave, but I.C.W. stations use slightly different waves for traffic to reduce interference. The 800 metre and 220 metre waves are also used for ship and shore work.

The Operators.

The Washington Convention has raised the Morse qualifications for ships' operators, the speed of operation required for a first-class certificates being now 25 words a minute, and for a second class 20 words a minute. The second-class certificate is that normally required, as it is only in the large liners that operators with first-class certificates are necessary. Small ships which are not compelled by law to carry wireless installations may employ an operator with a lower grade certificate, called the "special certificate."

There are some 4,000 operators on British ships, and about 85 per cent. of these are in ships which carry only one operator. Candidates for the post of ship's operator are trained at various privately-owned schools throughout the country, and the examinations for certificates are conducted by the Post Office.

All British ships fitted with wireless must carry a licence from the Postmaster-General, and all operators employed must be in possession of the Postmaster-General's certificate of proficiency.



A Ship's long-range Transmitter.

It will be noticed that no mention has been made of telephone services, because as a matter of fact there are no commercial telephone services of any importance yet in operation between ships, or between ships and the shore. The only services so far established are between a few fishing vessels and the shore, and between whalers, where the arrangement has proved of great value. But this state of inactivity is only the lull before the storm, and experiments in commercial communication between large passenger ships and the shore are now being carried out. The reasons for this apparently slow development of commercial wireless telephony will be explained in a future article.

In presenting TELEVISION *in its new form, the Editor desires to acknowledge the valuable assistance rendered him by Mr. Howard H. Cox, F.R.A.S., late Editor of the* POWER TIMES.

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Sydney A. Moseley's Captain

I OBSERVE that the late chief engineer of the British Broadcasting Corporation prefers the world of controversy to the control room. There is nothing like journalism, Peter. The public has a short memory. It is easier to play about with words than with valves, and there are more lines! I should have thought, in view of the *fait accompli*, that Master Eckersley would have climbed down, but he is made of sterner stuff, or, I should say, stubborn stuff. Obstinacy and consistency are terms which are often confused. The Die-Hard often mistakes himself as an honest-to-goodness fellow, and many a small-minded man has refused to give way in face of facts.

Captain Eckersley has a certain charm among his other admirable qualities which I should be the first to acknowledge, and I suppose there is no jollier companion. He can discuss all kinds of subjects, upon many of which he has the same unusual outlook which he has on television. I should like to join issue with him publicly on certain of these other subjects. But, this journal is devoted to television only! So for the moment we must leave the more piquant problems which he once raised during the friendliest meal imaginable, and devote ourselves to his latest diatribe on his pet aversion.

Captain Eckersley.

He says: "I have tried throughout my brief career with the B.B.C. to be truthful. A possibly Quixotic policy, and one that makes enemies."

"Strong, Stubborn, and Immovable."

Now, I am the first to worship at the feet of Quixotes and sincere opponents. Indeed, I often delude myself into believing that I am an equally honest and Quixotic sort of person, so that in point of fact Captain Eckersley and I ought to have got on very well.

Unfortunately, Captain Eckersley's unkind and unyielding attitude towards television was manifest when he was in the strong and not unenviable position of chief engineer of a great monopoly. Easy enough then, isn't it, to be strong, stubborn and immovable?

The big fight of television, so far as I am concerned, is over, and therefore I hope I can write without still being influenced by the stress of battle. Those of us who set out to obtain acknowledgment of Mr. Baird's invention have succeeded; and those who, until the last, suggested chicanery and financial ramps are no doubt feeling very sorry for themselves to-day. Captain Eckersley did not go so far as some of Mr. Baird's critics, who had not even investigated the subject for themselves, but, being a wireless expert, his attitude was more open to criticism inasmuch as he was always in the position first to inquire and then to help what the Postmaster-General in the last Government described as "a noteworthy scientific achievement."

"As one lives more with the idea of giving public service than of obtaining purely private gain, and as one's only prayer is to remain interested, the truthful and possibly Quixotic policy is not a bad one," says Captain Eckersley in *Popular Wireless*. He states that he has never attempted to disguise his firm belief that wireless broadcasting has nothing to do

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Replies to

Eckersley

with image-sending, still or living, " so long as the wave-length problem remains as acute as at present, and so long as the technical development and/or the service aspect of image-sending remains as at present."

Now you will notice that, although friend Eckersley asks us to accept his truthfulness, he is beginning to hedge from the Mussolini-like attitude he adopted when he was in power. The late engineer of the B.B.C. never said to the television people: " Yes, congratulations to Mr. Baird, you have achieved television, which I thought was impossible. We will help you all we can, *but* so long as the wave-length problem, etc., and so long as the technical development, etc., and more etceteras." . . . He said nothing of the kind. His whole attitude was more Puckish than painstaking. He impressed one as excessively egotistical and with a tremendous consciousness that what he said would go. I do not think that during that period of high-handedness he contemplated resigning his position, otherwise no doubt his criticism would have been tempered with a little more sympathy for an inventor who had striven almost single-handed in the face of world-wide competition and huge combines which strove to crush him. All I asked for was fair play for Mr. Baird. Nine Englishmen out of ten would have given it.

Inconsistency.

Captain Eckersley proceeds to say that he is " impressed as ever by the enthusiasm of the television and telepicture experts, but is unable to agree that in the present stage of development the science of television allows an immediate service aspect." That again I submit is not consistent with the attitude he adopted in the past. At that time it was possible for him to have co-operated in the *experiments* which are now taking place despite his expert advice. I cannot disguise the fact that the delay has not helped either the new science or the Baird Company, which has striven valiantly in face of this amazing opposition. That he is wrong in further stating that by putting over television transmissions it is not possible to improve the device was seen at once after the first three or four transmissions by wireless.

It fell to my lot to supervise the programmes and to do the announcing—this by way of a change. The first morning's transmissions from the Long Acre studio showed a distorted image, and for the moment we began to wonder whether the hard-boiled critics had not an element of justice in their cynicism when they said " that while television could be put over on lines, it was an entirely different matter when it was put over by wireless." The fact remains that after the second day the picture improved 25 per cent., and on the third day was twice as good as that on the first, and I have no doubt that it will go on improving until we get a perfect picture. That is where I have always joined issue with Captain Eckersley. He has been content to theorise, whereas I have always written from first-hand knowledge. I stated at the time when people were denying it that it was possible to recognise an image, and that I had *seen the image*. Most of the critics had not.

Readers have only to compare the two articles that appeared side by side in *Popular Wireless* a year or so back when I told *what I had actually seen* in the Baird studios, and Captain Eckersley was briefed to say what *he thought* was happening. Now he is continuing this rôle of armchair critic with equally ludicrous results. He states in *Popular Wireless* that " the microphone does not pull itself together as it sees the white shirt-front and black tie of the announcer and say: ' Now I'll improve myself. I'm on service.' " True. Yet it is beyond all possible doubt that the

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engineers have been able to adjust the lines with the resulting improvements I have mentioned above.

Captain Eckersley, I am afraid, did not increase his prestige in his profession and respect among his friends by the attitude he took up towards television. He must have known when he visited Germany that our friendly rivals there—no mean engineers, too—took a totally different attitude on the subject than he did. They were grappling with the subject seriously and with business-like intent. They were not rude to inventors; they went so far as to subsidise a Hungarian who claimed to know something about television.

How far his attitude has aroused the country may be seen in the striking letter that has reached me from Mr. W. Barrie Abbott, B.L., C.A., a prominent lawyer and lecturer in Secretarial Practice at Edinburgh University. Mr. Abbott is really reinforcing what I have said again and again in TELEVISION. He protests against the "bolstering" up of foreign experimenters at the expense of a British inventor.

This is what he thinks of Captain Eckersley's and the B.B.C.'s attitude to television; he describes it as "reminiscent of the man who would not allow his son access to any musical instrument and then blamed him for not being able to play!"

Baird has demonstrated conclusively (he writes) that with the small ration of ether given him he can produce small television pictures in clear-cut detail, but if the B.B.C. refuse to grant the necessary wavelengths for other performances which television can produce, it is not for them to try and gull the public into believing that the fault is other than their own. This is how the B.B.C. are behaving:

"Instead of welcoming and encouraging this marvellous British invention, the wireless authorities in this country appear to have done their utmost to belittle and discourage it; and even at this date, when impartial observers give glowing testimony to the clear-cut results shown in recent demonstrations, we have men of Captain Eckersley's standing in the wireless world solemnly telling his readers that British television is 'merely a mechanical toy.'

"In his concluding sentences Captain Eckersley says: 'Something ought to be done to stop this idea that the B.B.C. are holding up a great British invention. As I see it, they are in this case trying to uphold the rights and interests of the majority.' I would suggest that the way to stop the holding up is for men like Captain Eckersley to press for British television being given a fair chance to show what it can do, and to cease 'bolstering up' foreign experimenters. The contention that the majority of wireless listeners are not interested in this wonderful new science is not founded on fact.

"... They (the B.B.C.) do not seek to deny that British television can produce simultaneous transmission of sound and vision, but they refuse to give it the chance, and, worse still, they deem the occasion to be of so little interest that in announcing the day's programme they cannot afford to devote even two or three lines to any special announcement of this epoch-making transmission!

"It is interesting to analyse some of the statements contained in Captain Eckersley's article on television appearing in a recent issue of *Popular Wireless*. He says: 'I have never attempted to disguise my firm belief that wireless broadcasting has nothing to do with image-sending'; and in the same week in *Amateur Wireless* we have Dr. Gradenwitz writing about the German Wireless Exhibition, stating that 'undoubtedly the great sensation of the show was television. Television in Germany may be said to have been definitely adopted as a valuable adjunct to ordinary acoustic broadcasting.' In Germany the British system has been acknowledged and taken up by the Government purely on its merits.

"Of all the unpatriotic actions that have been done by so-called friends of their country, few can be so glaring as the attempt of vested interests and wounded *amour propre* in Britain to hold up British television. For a long time now, and right up to the present moment, British television has been and still is synonymous with Baird television, because there is no other British system in existence.

"I write this article in no unfriendly spirit to the B.B.C. or anyone else, but rather as a plea to the

THE SECRET OF THE MACHINES

We can See!

We were taken from the ore-bed and the mine,
We were melted in the furnace and the pit—
We were cast and wrought and hammered to design,
We were cut and filed and tooled and gauged to fit.

Some water, coal, and oil is all we ask,
And a thousandth of an inch to give us play:
And now if you will set us to our task,
We will serve you four-and-twenty hours a day!

We can pull and haul and push and lift and drive,
We can print and plough and weave and heat and light,
We can run and jump and swim and fly and dive,
We can see and hear and count and read and write!

Would you call a friend from half across the world?
If you'll let us have his name and town and state,
You shall see, and hear your crackling question hurled
Across the arch of heaven while you wait.

Though our smoke may hide the Heavens from your eyes,
It will vanish and the stars will shine again,
Because—for all our power and weight and size—
We are nothing more than children of your brain!

—RUDYARD KIPLING.

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British wireless authorities to change their attitude in the direction of befriending their own country." This is a rather strong letter, but not a whit less than was needed in the circumstances. Had Captain Eckersley ventured from the field where he has been so woefully defeated we might have left him alone, but since he has ventured again into the realms of public controversy there is nothing else to do but to smite him once again.

As to what is likely to happen as a result of these experiments it is too early to say. The battle has raged so fiercely and so long that I admit that the sudden ending took me somewhat by surprise. In the past there have been so many snags, so many "ifs" and "buts" that I imagined that something of the sort would happen at the last minute.

Now this question of the manufacture and marketing of receiving apparatus is purely commercial. That does not concern me. However, I happen to be in the position of knowing something of what this receiving apparatus, which is to be sold to the public, must be capable of doing, and those who have followed the history of television know very well how rapidly the science has developed.

Take, for example, "tele-cinema" and tele-talkie, or to give its fuller name, "talking cinematograph films." The transmission and reception of these films by means of television apparatus opens up a tremendous field of practical possibilities. Or take another example. The Baird Company has successfully transmitted and received written bands of messages by television. This is called "telelogography"—rather a big but necessary word—the etymology of which is interesting. (It should, by the way, open up a field for discussion in journals, both for literature and wireless!) The second "og," as Lord Ampthill points out, is a necessary adjunct, since without it the word becomes truncated and the etymological value is lost. Thus you may take it as official that these written messages conveyed by means of television are called "telelogography."

And here is another interesting point. Few are aware of the large number of deaf people there are. *Actually there are no less than* 1,500,000 *of these thus afflicted in this country.* These cannot "listen-in," *but they can "look-in."* For them the cinematograph films and the news bulletins will be sources of unparalleled interest. They will no longer be shut out from the entertainment of wireless transmission.

Yet it must be obvious to all readers that any apparatus which is put on the market must be capable, not only of good quality so that transmitted objects may be seen at their best—that is, technically!—*but it must also be capable of giving the very best reception.* It would be a definite disservice to the public if the market were flooded with apparatus "nearly as good." *We must give the public the best.*

Finally, readers must remember that the experimental transmissions that are proceeding at the present time are on one wavelength only. The tests are of the utmost importance and of infinite use and will enable us to make the fullest use of the two wavelengths shortly to become available for both sight and sound simultaneously, without which a television service to the public would be incomplete.

RULING THE WAVES

Those who read the article by Dr. Robinson on "Television and Photo-telegraphy" in our last month's issue will be interested in the following which appears in our contemporary *Nature* under date October 12th:—

"Photo-telegraphy and television are new industrial applications of science which make use of the ether. Being late-comers, they find that the earlier users of radio-communication have in all countries combined together to dictate the kind of waves that must be used in the ether. International laws and regulations have been made. The ether waves have been divided up into frequency bands, practically all of which have been allocated for various services. The authorities have little, if any, interest in the development of radio-optics. The present frequency band has a maximum breadth of 9,000 cycles, apparently because this is the breadth of the band used in radio-telephony. We are glad, therefore, that Dr. James Robinson has in TELEVISION for October strongly protested against this monopoly of the ether. He points out that the common interests of those who are working or interested in radio-optics are the same. They should combine to improve the methods used in this science, and increase the facilities afforded for its development. If we ignore the factor of time, there is no fundamental difference in the principles of photo-telegraphy and television. In the latter case it is necessary to transmit a complete picture in less than a tenth of a second; the pictures succeeding one another as in a cinematograph, and thus giving the appearance of continuous motion. At present, organisations all over the world are working at this problem. At the recent radio exhibition at Berlin, the Baird, Karolus, and Mihaly systems were demonstrated. The German Post Office gave an excellent demonstration of television. The stand of the Fernseh A.G., which showed the Baird system, was very popular."

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Our Twenty-

A PAGE OF

From Sir Richard Gregory, F.R.A.S., Editor of "Nature."

"Best wishes for progressive development. Perfect television is bound to be achieved eventually and you are performing valuable service in securing interest in it."

From John Logie Baird.

"I congratulate TELEVISION on reaching its twenty-first issue. In the development of a science the power of the printed word cannot be gainsaid. Your magazine is a pioneer in that important field, and I wish it every success.

From Prof. E. V. Appleton, M.A., D.Sc., F.R.S.

"Hearty congratulations on reaching your twenty-first issue. TELEVISION is doing pioneer work. I note, with appreciation, that its contents deal not only with practical developments but also include articles on the fundamental physical problems of the subject."

From J. Robinson, M.B.E., D.Sc., Ph.D., M.I.E.E., F.Inst.P.

"On the appearance of the twenty-first issue of the TELEVISION magazine I send my heartiest congratulations and best wishes. Its pioneer work in television has been excellent, and I look forward to seeing still greater results from its activities."

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First Issue!

GREETINGS

From Major A. G. Church, D.S.O., B.Sc., M.P., Editor of "The Realist."

"Heartiest congratulations on your twenty-first issue. You have succeeded in attracting contributions to your columns from among the acknowledged great ones of science. Any number of your journal provides a feast for the technical and the non-technical reader—for the former class because of the up-to-date and authoritative information which the number contains; for the latter because of the clarity of the expression of technical information. Your journal, like the invention which gave it birth, is something of which Great Britain can be proud."

From E. E. Fournier d'Albe, D.Sc., A.R.C.Sc., F.Inst.P.

"Hearty congratulations on the success of your pioneering work. Keep your lead and win the reward of brilliant achievement."

From Sir Ambrose Fleming, M.A., D.Sc., F.R.S.

"I send heartiest congratulations to Editor of world's admirable first television journal on its twenty-first coming-of-age issue."

From C. Tierney, D.Sc., F.R.M.S.

"Our knowledge of the science and art of television is rapidly increasing, and I send you hearty congratulations upon the twenty-first issue of the world's first television journal, which has played so significant a part in the advancement of that knowledge and in the development of this new and important art."

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Photographing a Television Image

By *A. F. Birch*

in collaboration with *D. R. Campbell*

Fig. 1.

UP to the present there has been a remarkable dearth of authentic camera records of television pictures as seen on the screen itself, and sceptics have not failed to take advantage of this apparently significant fact. The very few photographic attempts which have been made, generally speaking, showed such poor results that, considered as a sample of what television had to offer, they were quite unsuitable for publication. With the advent of broadcast television there arises the necessity for providing some genuinely comparable specimens of images before and after the television process. These will serve both as a guide to the prospective televisor purchaser and also will inaugurate a standard of obtainable results compatible with the true merits of Mr. Baird's invention.

A Pioneer Effort.

In order to meet this need, therefore, the writers have been at some pains to overcome the several problems presented, and it may prove interesting to describe steps taken to secure the series of photographs published herewith. These are by no means perfect and must not be accepted as portraying television reproduction to its best advantage. The reverse rather is the case, but nevertheless if only from the viewpoint that they represent a more or less pioneer effort and certainly do provide sufficiently good results for analytical purposes, they are interesting, and incidentally have paved the way for some perfect television photos which will shortly be published.

We will assume, to begin with, that the reader is familiar in principle, at least, with the Baird system of transmitting and receiving television, and therefore it is only proposed to discuss the actual photographing of the image as produced by this process. Now a person looking at such a picture in a televisor is conscious of seeing a uniform image with just a trace of a transverse flicker, comparable with early cinematography except for the direction of the flicker, but, when we attempt to produce a photograph of that picture, we have to consider the problem from the angle that it is built up by a rapidly moving spot of light and that the cameratic eye has somewhat different recording characteristics from the human eye.

The custom at present in broadcast television is to send 12·5 pictures per second, that is to say, the travelling light spot explores the image from one side to the other every ·08 second. The grain or number of strips formed by this spot each traversal being 30, the time taken to describe every individual strip is ·08÷30=·0026 second and the period for the spot to travel its own length is correspondingly smaller, the exact time depending on the ratio of the picture in terms of length and breadth. Upon measuring this latter from a negative taken of a received image, the size was found to be 17 mm. ×29 mm., which meant that the dimensions of the spot were equal to 17÷30=·56mm. square. Now 29÷·5=58, therefore, dividing ·002 seconds (the time occupied by each scanning strip) by 58 (the number of light spots per strip), gives us the illumination time for any given spot

Fig. 2.

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ng each separate picture on our photographic e, *i.e.*, approximately ·00003 second.

his light, such as it is, emanates from a neon lamp, which is of a dull pinkish nature. Photographically-inclined readers will readily appreciate the difficulty of securing photos under such conditions. It meant that only the fastest lenses and emulsions could be considered. The photographs reproduced with this article were obtained using a cinematograph lens F/1·9 and with the exception of Fig. 4 a special panchromatic plate having an H. & D. speed of 2,000 to half watt electric light. Picture Fig. 4 was taken on a slower and orthochromatic plate, exposed for 40 seconds. The other exposures were timed from 6 to 8 seconds. We can easily calculate the actual time the emulsion itself is exposed during a lens exposure of, say, 7 seconds.

Fig. 3.

As we have seen, each spot reaches the plate for the very small period of ·00003 second, and, moreover, after a spot has been exposed to the plate that portion of the plate is in darkness for the remainder of the complete scanning time, *i.e.*, 1/12·5 of a second. So that in contradistinction to straight photography the lens exposure time does not coincide with the plate exposure time. ·00003 second represents the exposure of the plate per spot and also per picture, and thus a 7 second lens exposure is equivalent to $\cdot00003 \times 12\cdot5 \times 7 = \cdot0026$ seconds plate exposure, roughly 2 thousandths. This nevertheless registers a really good picture density on the negative, and one considerably better than a great many amateur snapshots.

Effect of Movement.

From the rough calculations presented, it should be apparent that the person or object at the television transmitting end must remain stationary, or almost so, throughout an exposure, and this would still be essential even if the duration of the exposure could be drastically cut, or the speed of the scanning were varied, or even were we able to limit our exposure to the time taken by just one single picture, *i.e.*, 1/12·5 seconds. Anything in the nature of quick movement would cause distortion to be present on our photograph of the variety produced when taking a picture with a narrow slit focal plane shutter of an object travelling at high speed across the plane of vision. One might raise the query that surely if distortion can be present in a photograph of one spot traversal, it must also be obvious when gazing at a television screen. Such is not the case, however, owing to the inertia of the eye or some similar psychological effect hard to define unless we compare it to seeing things stereoscopically with one eye closed. In addition, it is well to remember that a close inspection of a cinematograph film of a fast-moving object reveals on each individual picture a noticeably blurred effect which is certainly not seen during the film's exhibition, probably for a similar reason.

It is quite feasible that with the same neon lamp and apparatus used to secure these reproductions, the exposure might successfully be reduced to 2 seconds. Again, if we could increase the actinic value of the neon or substitute some other form of light equally efficient in its response to television requirements the time could be still further reduced, the limit being the single picture period of 1/12·5 second.

It was found that the pictures could be made either "hard" or "soft" by regulating the signal strength applied to the neon. As in ordinary photographic practice, a hard picture will stand out boldly, but on examination is found to lack the finer tones of a soft picture. The examples herewith are of the hard variety, but softer and more pleasing photos will be taken and published later on.

Pictures Nos. 1, 2 and 3 are of the writers themselves and are faulty in several respects. It can be seen in 2 and 3 that the lighting of the left-hand side is lacking. This was caused by the accidental displacement of the neon to one side during operations. In 1 and 2 it is also obvious that the sitters are placed too high up on the screen with the result that the delineation of the head has suffered. The vertical black and white lines common to all are traceable to mechanical imperfections in the discs receiving and transmitting.

Fig. 4 was included purely for analysis. In it the reader may detect all the defects likely to be present in television reproduction by the spotlight method as explained in the article entitled "The Spotlight Principle in Television," published in the June number of this magazine. We notice that the tops and bottoms of the two circles are portrayed comparatively accurately, but not so the sides. The strips have introduced the jagged outline which one is led to expect, and also the width of the bands has expanded out of all proportion to the original due to the mean value of current set up in the cells at the transmitter at this point. At the same time the circles retain their correct shape if we can overlook the linear inaccuracy, and shows that Mr. Baird's system responds to certain theoretical limitations in quite an orthodox manner, despite the fact, as we know, that the tolerance of the human eye almost discounts these when looking at the screen itself.

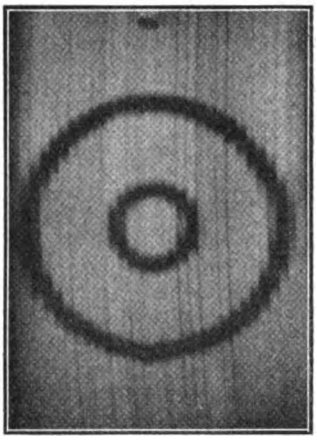

Fig. 4.

EXPERIMENTAL work. Inventors' models. Scanning discs any size to drawings. JOHN SALTER, Scientific Instrument Maker. Established 1896. Featherstone Buildings, High Holborn, W.C.1.

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TELEVISION
Broadcast by the B.B.C.

The Inaugural Programme Transmitted on September 30th

ON Monday, September 30th, 1929, the inaugural broadcasts of television were sent out by the British Broadcasting Corporation from their London Station 2LO. The event was made the subject of a special programme, the details of which we give below:—

11.4 a.m.—

Mr. S. A. MOSELEY, in his capacity as announcer, said:—

"Ladies and Gentlemen,—You are about to witness the first official test of television in this country from the studio of the Baird Television Development Company and transmitted from 2LO, the London station of the British Broadcasting Corporation.

"On this inaugural occasion we are very fortunate in having with us Sir Ambrose Fleming.

"I must explain that as the facilities for broadcasting both *speech and vision simultaneously are not yet available*, we shall transmit first of all speech, and afterwards those of you who have televisors will have an opportunity of seeing the speakers. Listeners not yet in possession of televisors should leave their sets tuned in in the ordinary way.

"Before asking Sir Ambrose to address you, I have a message from Sir William Graham, the President of the Board of Trade, which I shall read to you."

MESSAGE FROM THE RT. HON. WILLIAM GRAHAM, P.C., M.A., LL.D., M.P., PRESIDENT OF THE BOARD OF TRADE, MEMBER OF THE BRITISH CABINET.

"It was with great pleasure I received the invitation to speak and be seen on this occasion of the first public experimental broadcast of television and I deeply regret that circumstances prevent me from being present.

"I look to this new applied science to encourage and provide a new industry, not only for Britain and the British Empire but for the whole world.

"This new industry will provide employment for large numbers of our people, and will prove the prestige of British creative energy.

"In this first public broadcast, we have a beginning which will be historic in the evolution not only of a science but of an art which will encourage closer relations between communities at home and abroad and provide a new avenue for educational development."

Sir Ambrose Fleming and Mr. J. L. Baird before the television transmitter on Sept. 30th.

11.8 a.m.—ANNOUNCER: "Sir Ambrose Fleming will now be televised for two minutes."

11.10 a.m.—ANNOUNCER: "It is now my pleasure to call upon Sir Ambrose Fleming to address you. It is hardly necessary for me to say that it was due to the untiring work of Sir Ambrose, in the early days of wireless, that radio broadcasting, as we understand it to-day, has become possible. Now Sir Ambrose Fleming will say a few words."

SIR AMBROSE FLEMING: "As President of the Television Society, I have great pleasure in saying a few words of congratulation both to the Television Company and to the British Broadcasting Corporation on the inauguration of a new departure in the art of television. It will, I am sure, contribute to the pleasure of countless persons and assist in the creation of a new industry which owes so much to the genius of Mr. Baird."

(*Continued on page* 471.)

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NOW!

Where *do* We *go from* Here?

By *Leslie Trenton*

THE Radio Show of 1929 will go down in history as the culminating achievement of sightless broadcasting. Its extent represented a brilliant effort on the part of manufacturers to revitalise a flagging industry through an appeal to man's love of variety. Fundamentally, the specifications of the sets themselves incorporated no wide departure from those previously exhibited but clothed in less ambitious exteriors.

Neither is the Radio Manufacturers' Association to be criticised on this account; on the contrary, it is to be congratulated on the uniform lay-out and efficient organisation of an exhibition that drew a record crowd. But, as was inevitable, there was a monotonous sameness about the displays of competitive exhibitors which proved to be as tiring as it was disappointing.

Blindfold Entertainment.

What was the matter? The answer is not far to seek. Manufacturers have come to the end of the tether in their attempts to devise anything revolutionary in the way of receiving units for a public that daily grows less tolerant of blindfold entertainment. The solution proved nearer than many supposed, however, for what in some quarters had been the subject of misapprehension now looked like becoming a timely blessing.

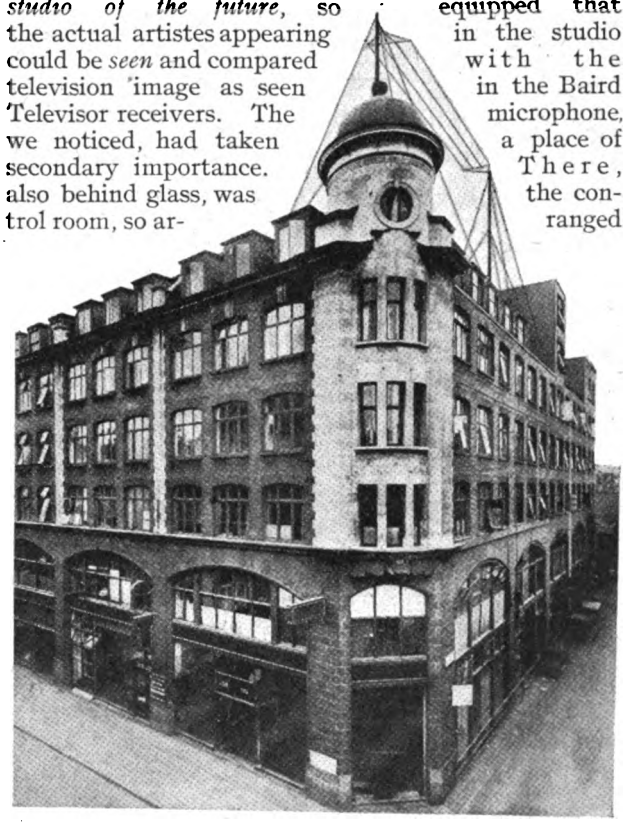
Much has been written in the newspapers and elsewhere about television, but until now the name has suggested to the public mind something more fantastic than practical, more of a scientific accomplishment than a commercial enterprise. Even the most credulous failed to grasp what this new invention would mean to them, and many who, through their connection with the trade are now about to harvest profits in selling it to the public, were heard not many months since to place its commercial development ten years ahead.

When the Baird Companies decided to stage demonstrations of television at this year's Radio Show they had to face the fact that no suitable accommodation was available within Olympia itself. Demands for space in that building had exceeded all expectations and many would-be exhibitors were disappointed.

By a stroke of good fortune, however, an eminently suitable building, only a stone's throw from the Exhibition, was secured, and it was here—in the garage of the Olympia Motor Company—that the Baird apparatus was set up. Neither were any pains spared in an attempt to demonstrate the achievement and purpose of television.

Relating his impressions afterwards, one influential visitor declared that the thing which struck him most was the obvious desire on the part of the Baird Companies to show that they had "nothing up their sleeve."

Anyone who had seen the premises prior to the demonstration would have had extreme difficulty in recognising them in their new guise. The whole place was transformed. Here, behind a wide expanse of plate-glass, was a sound-proof room—*the B.B.C. studio of the future*, so equipped that the actual artistes appearing in the studio could be *seen* and compared with the television image as seen in the Baird Televisor receivers. The microphone, we noticed, had taken a place of secondary importance. There, also behind glass, was the control room, so arranged



The Headquarters of the Baird Companies in London.

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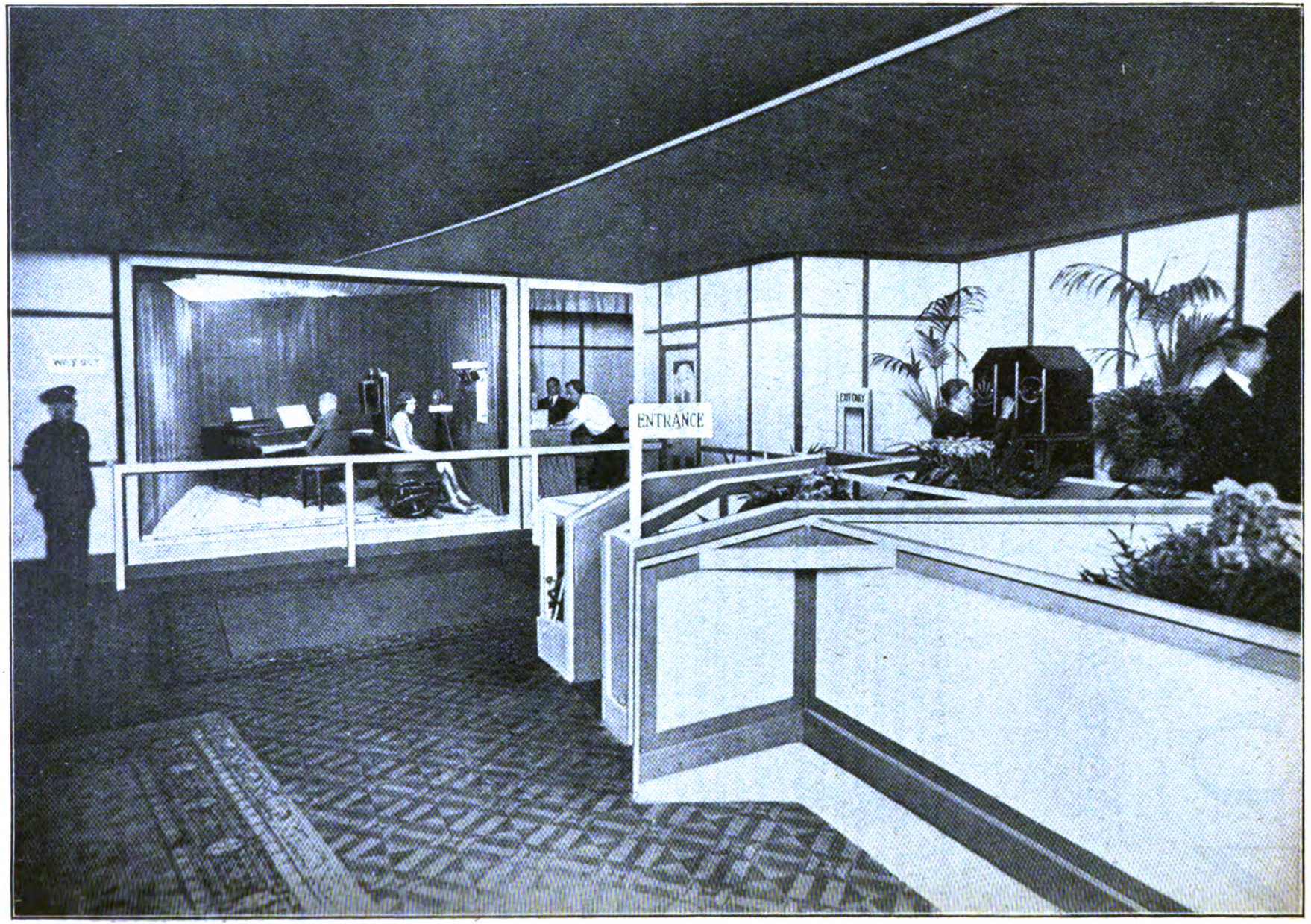
THROUGH A GLASS — BRIGHTLY!



A general view of the Demonstration Room used by the Baird Company in demonstratinq Television during the period of the National Radio Exhibition, held in London, Sept. 23rd–Oct. 3rd, 1929.—See accompanying article.

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as to make it possible for one to watch the engineers at work. Out in the main hall, mounted on their polished mahogany stands, were the Baird televisor receivers. These, it was explained, were units similar to those we should soon have in our own homes. For purposes of the demonstrations they had been placed on a platform at a height which brought the television image to the eye-level of visitors whilst standing. Much has been written and said by critics as to the smallness of the television image. At the demonstration now described the point fell into insignificance as one realised that it is not a question of the extent of the field so much as it is good definition of the face which really matters. In other words, it is the interaction of facial expression and intonation of voice which now makes it possible to put the *personalities* of our great actors and actresses on to the ether.

A Perfectly Clear View.

A glance at the accompanying photograph will give a good idea as to the facility with which those who visited the demonstration passed in file before the televisors. The aisle farthest from the studio was raised several inches higher than its fellow, in order that everyone might have a perfectly clear view of the artistes at work in the studio and in turn compare them with the televised image. No dull, indecipherable thing, this image, but a bright lifelike reproduction pulsating with the personality of the artiste. A visible enthusiasm came over all who stood before the televisors.

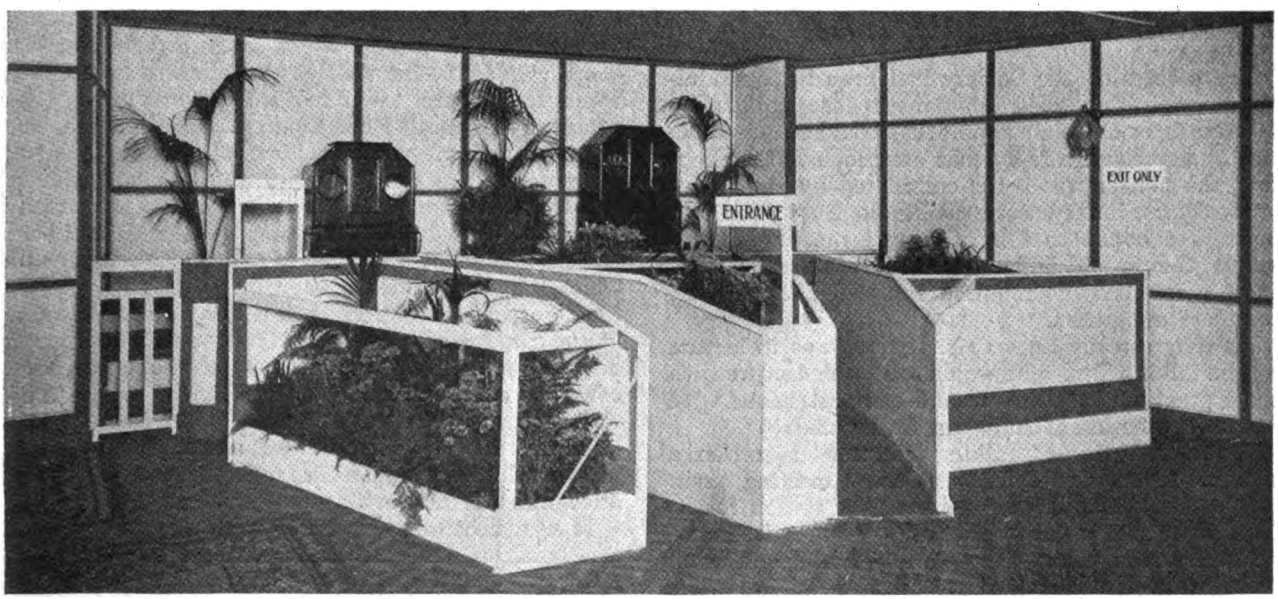
Here was the solution to many existing difficulties in the trade and the basis for a new prosperity. Here was the new factor which would vitally change the radio shows of the future. They realised the significance of marrying the new invention with the radio business, since those wishing to pick up the television signal *must* purchase another wireless set in order to do so, and that on that score alone the advent of

The Baird Television Transmitter as installed in the Control Room for the demonstration described.

"seeing-in" will revitalise the radio industry and give it the greatest fillip it has had since its inception.

Henry Ford has called this the "bridge" age. He meant, of course, an age of transition. But how singularly applicable his term is to the achievements and methods of modern communication and its greatest achievement, television—bridging space and transporting us as if by magic to remote quarters of the globe and enabling us *to see* what is taking place while it is happening.

During the period of the Exhibition many thousands made application to see the television demonstrations. A perusal of the counterfoils of tickets issued leads one to speak of them as truly representative of the radio industry. Leading manufacturers and retailers from all over Great Britain, as well as many people from abroad, spoke in glowing terms of their impressions. They realised that television has stepped right out of the experimental stage in which it had been for so long and is now ready to be commercialised.



The Baird Televisor Receivers in position for the Demonstration. Note the angle of the gangways, making it possible for eight people to "see-in" at the same time.

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THE Proceedings OF The Television Society

The Winter Lecture Season Opened

THE opening meeting of the winter session of the Television Society was held at the Engineers' Club, Coventry Street, London, W.C., on Tuesday, October 1st, when an illustrated lecture was given on "Talking Films" by Mr. H. S. Ryland.

Dr. Clarence Tierney, the chairman, opening the meeting, referred to the television transmissions which were being given daily from 2LO, and said that these naturally raised the question of securing sets of parts, or the complete apparatus, so that members and fellows might be in a position to receive the transmissions.

The Baird Company Approached.

The officers of the Society had been in communication with the Baird Company to ascertain when such parts, or complete apparatus, would be available, and had received a reply that afternoon to the effect that the matter was being considered by the Board of Directors, immediately the Radio Exhibition was over. He hoped that by the next meeting, if not before, they would have some useful information for those amateurs who required essential parts, or the complete apparatus.

As they already knew, Mr. Ryland was to lecture on the talking film. He would follow his lecture with some practical experiments and demonstrations. He had great pleasure in calling on Mr. Ryland.

"You may think 'Talking Pictures' is rather a strange subject for a Television Society meeting," said Mr. Ryland, "but there is quite a good reason for it. They both run on parallel lines, the great difference between them being that one—television—is using what to us is an intangible medium—light—while the other employs a medium we can compress, freeze, and do all sorts of things with—the atmosphere.

"In talking pictures, you want, in some way or other, to impress the result of sound on a film, and to translate it afterwards; whereas, in television, you want to transmit a picture of something seen, and reproduce it again, practically immediately."

Dealing briefly with these points of difference, Mr. Ryland showed a lantern slide of the human eye, which, he said, was really a camera and took account, more particularly of direction and in a secondary sense, of wavelengths of light in terms of colour and intensity, but the eye's primary function was to take notice of the *direction*. In the case of the ear—which he also illustrated with a lantern slide and explained how it operated—attention was not paid primarily to direction, but more to intensity and wave form. In other words, the human ear was adapted to analyse wave form and take account of intensity. The problem was parallel but different. In one case, one dealt with impressions as a whole (case of sound), whereas, in the case of light, the receiving device must take account of what passed before it, part by part. To explain the reason why sound could be treated as a whole, the lecturer referred to a record on which it was possible, on one tiny track, to record all the different instruments, even if they were all playing at the same time. Although there were a number of different sounds, all of them, at any one moment, could be represented by a single wave form. This wave form might change its shape, but it could still be represented by a single wave, and it was that wave form of which they wanted to take account, and reproduce, in connection with talking pictures.

It was because they could represent sound by a

Our title illustration is of particular interest to members of the Society. Right to left: J. L. Baird, Sir Ambrose Fleming, N. B. Reynolds (Hon. Fellow), and W. C. Keay (Treasurer of the Society).

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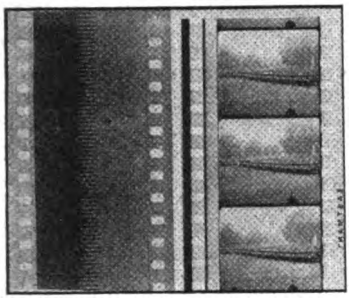
single wave form that a disc or film suitably treated would reproduce at one and the same time the different instruments in a jazz band.

The next point in connection with talking films was how to make the records, and he proposed to confine himself entirely to that type of record made on the film carrying the pictures, the reason being that, as far as he could see, it was the only method of ensuring, at all times, absolute synchronism between picture and speech.

The problem was that the sound waves which were being sent out had, in some way, to be made to control, first a light, which would be used to impress its changes of brilliancy on some medium which would, in its turn, be used later to modify a beam of light falling on a light-sensitive device, and so control, or give rise to, electric currents fed to the amplifiers and loud-speakers.



Two forms of film record.

There were two forms of film record, and the next lantern slide showed both. In each case the sound record ran beside the picture. One was composed of a number of slits of varying density, and would be referred to in future as the "ladder" type, while the other was a wave form. Either type represented an actual sound recorded. These records were made in one of the following ways.

They must have a microphone from which the speech currents were amplified. In the one method ("ladder" type) a neon tube was inserted in the plate circuit of the last valve of the amplifier. The neon tube changed the intensity of light emitted, almost in proportion with the change of current, so that one saw the speech reproduced as a fluctuating light. The film was passed in front of a small slit placed in front of the neon tube, so that the tube produced a band of varying density on the film.

In the other type of record a different method was employed. Instead of the neon tube, a modified oscillograph was used, in which a fine horizontal beam of light was caused to move backwards and forwards by the speech current. This little beam of light, as it moved, traced the actual sound wave on the film.

In a third form the Kerr cell was used, which varied the light passing through two crossed Nicol prisms and so gave the light changes necessary to form the record.

Those, briefly, were the methods used in making each type of film.

Realism.

Considering the chief points which determined whether either type of film would be satisfactory, they had first to insist on realism, for without that the talking film would ultimately fail. The slit through which the light passed to make the record had a finite width, and that width had a definite effect on the record. If the frequency range was twice the slit width half the film space would be wasted, and in this way the slit placed a very definite limit on the frequencies that could be recorded. The most they could afford to waste was a quarter of the film space.

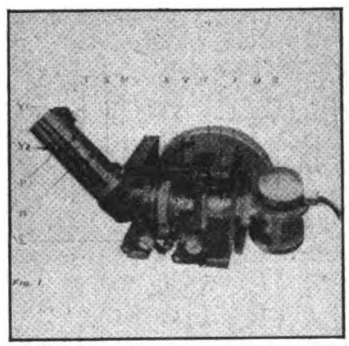
In ordinary practice films ran at 18 inches a second, and to get a sound record of 18,000 the slit would have to have a width equal to half the highest frequency to be recorded. At present the highest frequency which could satisfactorily be recorded was 4,500, and in the present state of the art was as high as one ought to try and go, for it must be remembered that the film space devoted to the sound record was small, operators did not always take special care of the film and they occasionally got marked and sometimes torn, all of which had their influence. It must not be forgotten that a small spot of dust, or similar mark, had only to be 1/1,000th of an inch in size to become audible, and very much so, through the loud-speakers.

Reproduction.

In order to get perfect reproduction from the talking films they should be run at a much higher speed than 18 inches a second, but the film people would not run their films so fast.

Even under present conditions, to get the last degree of perfection from a film, it should be reproduced with exactly the same sized slit as that with which it was taken.

If the "wave form" of film record was used, where sound charges depended solely for reproduction on the relative widths of light and dark, they were independent of photographic development. In the "ladder" type, development and the type of film used had to be very carefully selected to ensure that the changes of density remained proportional. In other words, a good film could be spoiled by careless development, or by using the wrong type of film. The purpose of the film was to modulate, or change, the intensity of a beam of light. Therefore, the more pronounced the change between black and white the better the reproduction, because it reduced the amplification required. With a film moving in a given direction at a definite speed the peaks of a high frequency got an entirely different exposure from that of the peaks of a high amplitude. When high frequency and high amplitude came together the peaks of the wave form almost disappeared, and were useless for reproduction purposes; these conditions applied to both types of film.



The "sound-head."

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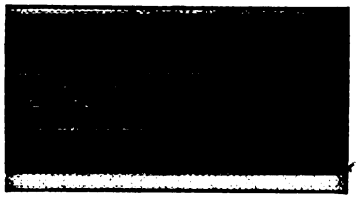
In reproduction the film was used to modulate the intensity of a beam of light. This was in its main details done by focussing the beam of light on to a slit, so that it was fully illuminated. The image of the slit was picked up by a lens system, and a reduced image of it formed on the film, so that as it moved the ladder markings, or the wave form of markings, caused more or less obstruction to the beam of light passing through. After passing through the film the beam of light was picked up by a further lens system, made approximately into a parallel beam, and allowed to fall on a selenium or photo-electric cell. Another method was to focus the light direct on to a fine slit and run the film just in front of it. The light from that point was picked up and focussed on to a cell. That system did not find much favour because the film, being run close to the slit, was soon destroyed.



Three photographs of the tone of a flute played p, mf, and f.

When "showing" the film there were one or two points which required watching. Any cinematograph machine, when running, created vibration, and very little vibration was required to move the beam of light. If this happened, distortion, in one form or another, was sure to occur. If there was to be any movement of the parts dealing with the sound reproduction, they had all to move together. No relative movement between them could be tolerated.

Also, when a film was passing before the "gate" of a normal picture machine it went in a series of jerks. For a sound film it was imperative that it moved forward with absolute steadiness. This was secured by attaching the apparatus which dealt with the sound 21½ pictures below the "gate." The loop thus formed allowed the film to be jerked past the "gate" as in normal cinematograph practice, and yet be steadily fed past the portion responsible for the sound reproduction.

Lantern slides of the "sound-head" were shown, and Mr. Ryland explained the mechanism, pointing out that the "gate" through which the film passed here was most carefully made, so that the film was not scratched or torn, nor must it be allowed to flap.

Often, to prevent roughness and wear, the "gate" was chromium plated. Absolute steadiness and uniformity of speed in passing through was another essential, and this was usually secured by a heavy fly-wheel controlling one of the feed cogs over which the film passed.

In both types of film it was obvious that the slit through which the reproducing light passed had not only to be the same size as that through which the film was made, but it also had to be absolutely square with the film. The slightest want of squareness in the positions of either was disastrous to the reproduction of sound.

The Photo-electric Cell.

For talking film work the photo-electric cell was practically universal. As an amateur, he was very fond of selenium for the purpose, and had found it, when properly made and balanced, quite satisfactory. It definitely gave the whole of the frequencies and, further, saved a considerable amount of amplification. The output of a photo-electric cell was of the order $\pm 7^{-6}$ of an ampere, whereas a selenium cell passed ± 8 micro-amperes. A selenium cell, properly made, was practically permanent and was thoroughly reliable.

Synchronism was the next point. If a record was taken fifty feet away from the source of sound, and reproduced to people sitting fifty feet away from the screen on which the picture appeared, synchronism would appear absolute. If, however, the nearest person was one hundred feet away it would at first sight appear that the synchronism was somewhat wanting. On thinking it out, it was apparent one did not complain of a want of synchronism at a theatre, because one automatically made a mental allowance for the fact that sound travelled at a slower speed than light. Trouble with the talking film was caused through change in the position from which the sound was recorded, either through the actors moving about, or a change of scene, and from inaccuracies in printing.

Unsatisfactory reproduction also could be caused by taking a record at one volume and reproducing at another. The cause of this was clearly illustrated by the slide showing a record of the note of a flute played softly, louder and still louder. The first wave was practically a plain evenly-waved line. The next was beginning to show the effect of harmonics in breaking up its regular form, while the record of the loudest note showed clearly the harmonics. If one took a record of the softly-played note and reproduced it at a volume equivalent to, or greater than, that of the loud note, it would obviously lack in realism because of the absence of the harmonics. To be strictly realistic the reproduced sound ought, at a given point, to have exactly the same volume as the recorded sound had at the corresponding point.

Other Methods.

The methods just outlined, of making talking pictures so far as the talking side was concerned, were those in general use, but one or two other systems had been suggested. One such method proposed to make a sort of gramophone track on the edge of the film. The method was interesting, but was hardly likely to prove very practical having regard to the nature of the film and the amount of handling it had to withstand.

Another method was to make the sound record on a steel strip. In this system the strip was passed between the poles of an electric magnet fed with the speech currents coming from the amplifier. The changes in magnetism so produced magnetised, more or less, the strip as it passed between the poles. To reproduce the sound when recorded the steel strip was run between the poles of another magnet, and this set up small currents which, after amplification, were used to work the loud-speakers. After a certain amount of use and the passage of time this type of record was not as satisfactory as other systems.

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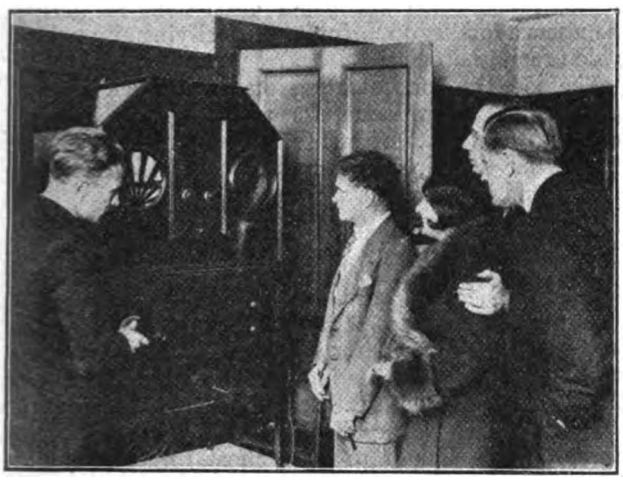
At the present speed of passing the cinema film through the projector, the amount of space available for speech reproduction was very small, and this defect, he thought, would have to be overcome. Two methods offered themselves. One was to have the sound record on an entirely separate film and the other was to increase the picture size.

This seemed to be the most fascinating way of overcoming the difficulty for it gave more space, and for other considerations also he would like to see the picture size increased. If one had the film enlarged and run at a higher rate of speed one could still have the same number of pictures per second, but there would be more space for the sound record.

With regard to the question of realism, he had visited a considerable number of theatres, not for the pleasure of seeing the film, but to see how many faults



A group of interested spectators looking in at the first inaugural broadcast of television on September 30th last.

in reproduction he could locate. The number of these was surprising. At one place visited two different people had precisely the same voice. They could draw their own conclusions from that. In another case certain voices came through very well, while others were very poor indeed. Most of the medium voices came through poorly, while both men and women who spoke with a deep tone came through very well. At the same time the higher notes in the voice were entirely out of proportion.

An Unfortunate Contrast.

Another fault in the theatres was that after a light musical selection had been played by the "talkies" it was followed by the theatre orchestra—a comparison which was too terrible for words.

A fault, which was not now so pronounced as it used to be, was to show a huge face in a close-up, while the voice that was supposed to come from it was utterly ridiculous in its volume.

Another point which no doubt would be dealt with very soon was that a different volume of sound, and often a different type of film, was required for different halls, and the number of people present.

Occasionally, when sitting in a hall while looking at the picture, the sound accompanying it appeared to come from the back of one's neck. As far as possible and in all cases the sound should emanate from the picture.

With regard to the future, if they were going to have talking films, or a realistic picture cinema, colours would naturally be required. That, he thought, would soon come. After colours, stereoscopic vision would naturally follow, but there seemed to be difficulties in the way of that, and at present he could only see true stereoscopic vision as a possibility, if every person present had a separate instrument with which to view the pictures. As a makeshift, one could close one eye, and get, thereby, quite a good stereoscopic effect.

Next, the picture must be projected on to the screen in something like its natural size. It was simply absurd to have people on the screen four times their normal size. Realistic reproduction of sound demanded that the pictures it was supposed to come from should be about the normal size.

When all those points had been attained they would have a form of entertainment which would have a place of its own. The theatre had its particular sphere, the silent picture had had *its* day.

But if one had talking pictures along the lines suggested, then they had a set of circumstances which would enable the producer to deal with larger spaces and movement than the legitimate stage could ever hope to touch.

The Coming of Television.

Looking a long way ahead—and in these days of rapid development that long way ahead might only be a year or two—he saw a time when, during a part of the entertainment, the management would switch on to television and an audience in a cinema theatre would see, in colours, with the corresponding sound, anything of news value that was happening at that time.

With regard to talking pictures and television, one could look for development along many lines.

* * *

Dr. Tierney said they had listened to a very fascinating lecture from one who must have spent a considerable amount of time on the subject of the relationship of light-sensitive devices to methods of recording.

It was obviously a problem which had not yet been completely solved, any more than the problem of stereoscopic projection.

Notwithstanding that, there was reason to believe that those problems were in the course of solution, and it was merely a question of time for the working out of the solution.

The possibility of bringing, by television, on to a large screen images of things which were actually happening was not so dim and distant as might be imagined. It was now a matter of development, and had, to a certain extent, already been done experimentally.

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During the discussion which followed the lecture Mr. R. R. Poole said he thought Mr. Ryland had been a little pessimistic with regard to the frequencies which could be recorded. 4,500 was not a very high figure. He had made some rough measurements with a microscope and a piece of film as used for the side band recording of sound, and the maximum size of the granules in it appeared to be somewhere about 1/12,000th of an inch. With a film running at a speed of 16-18 inches per second, one would have plenty of granules in the smallest size band that it would be necessary to record.

Assuming that one wanted to record a frequency of 10,000 per second, this meant 16 times 1/10,000th of an inch for the smallest band. That was to say, the smallest band would be 1·6 milli-inches in width. From those measurements it would seem that a frequency of 10,000 per second was not an impossible figure. He believed that British Talking Films claimed to have recorded a frequency as high as 15,000 cycles per second. This seemed rather high, as most amplifiers only handled up to about 10,000 per second.

Steel Tape Recording.

With regard to steel tape recording, he had heard one or two models of this in connection with a device for use in connection with automatic telephones, to make appropriate remarks to people who insisted on ringing when the line was engaged. This device murmured in a rather thick voice "Number engaged." Very often these words were not very distinct, due to fatigue in the metal. The greatest difficulty of that system seemed to be that, unless the strip of steel was run at a very high speed, the pole shoes had to be exceedingly narrow, with the consequent difficulty of getting sufficient magnetic density. He did not think that form of recording would be of much value for talking film purposes, because of the very great length of steel strip required.

Replying to the discussion, Mr. Ryland said he quite agreed with Mr. Poole with regard to frequencies. Experimentally, there was no limit to the extent he had pointed out. In fact, he had a film which showed the recording of a frequency of 16,000 per second, but the loss of definition on the peaks was considerable. This loss could be made up by using more of the film space.

He also quite agreed with what Mr. Poole had said regarding steel tape. He merely referred to that system in passing, but could see no useful future for it. The only satisfactory way to make talking pictures was to have the picture and sound record on one and the same film.

If a portion of the very large amount of money which the public found to support the film industry was diverted from the actual making of films and used for experimental work a good many of the small practical difficulties which he had mentioned would be speedily overcome.

Dr. Tierney, closing the meeting, reminded the members that on November 5th, the date of the next meeting, Mr. Langford-Smith would speak on "Amplification and Television," with experiments.

SOCIETY NOTES FOR NOVEMBER.

The opening meeting of the session, when Mr. H. S. Ryland spoke on the subject of "Talking-Films," was so well attended as to tax to the limit the available seating accommodation of the room we usually occupy at the Engineers' Club. This state of affairs it is hoped to remedy by securing a larger room at the same Club for future meetings. Some 200 members, their friends and visitors were present, and the discussion which followed the lecture was indicative of the keen appreciation with which Mr. Ryland had been followed in his remarks. It has since been felt, in several quarters, that, rather than attempt to raise *new* subjects for discussion at the next informal meeting on November 5th, it would be better to continue the same discussion, so giving members a further opportunity of clarifying any points which remain obscure.

The idea of concentrating on a few well chosen subjects is a sound one, for we have no desire to aspire to that state of mental indigestion that might arise from listening to two full lectures, staged on one evening.

The Next Lecture.

The matter has been referred to in a postcard recently circulated to all members of the Society, and suggestions are asked for in the circular which also announces the next meeting on November 5th, when Mr. Langford-Smith, B.Sc., B.Eng., will deal with the subject of "Amplification and Television" at 8 p.m. This should prove a most interesting and practical evening, as the lecturer is bringing apparatus with which to demonstrate some of the more important principles developed in the course of the lecture. Members will find that a careful study beforehand of the abstract of the lecture with which they have already been provided is very desirable.

The secretaries are always glad to meet the wishes of members by sending invitation cards for a particular lecture to friends who are themselves non-members of the Society. However, it cannot be too strongly urged on all who have the best interests of the Society at heart that they should do all in their power to increase the membership. Unity is strength in these matters as in others of more commercial import, and it is only by the banding together of interests that the scientific side of the development work can continue progressively.

Attention is called to the "Printed List of Members" (with addresses and class, with date of joining) which is about to be published and is already in type. Corrections to the printed list must be forwarded to the Lecture Secretary (Mr. Mitchell) by first post on Monday, November 4th. Corrections received later cannot be dealt with.

Members will be interested to hear that a very cordial letter has been received from the French Television Society in reply to the Society's suggestion towards international co-operation. The necessity for such mutual understanding seems to have been

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strengthened by a recent article from the pen of no less an authority than Dr. J. Robinson in the October issue of TELEVISION, dealing with the struggle to find a place in the ether for the newer methods of "communicating by seeing." We may perhaps look forward to some fruitful conferences in the next few years.

Group Centre Progress.

In connection with the formation of group centres lectures will be given at Barrow, Derby, Leeds, Liverpool, Manchester, Sheffield and Wigan during December, particulars of which will be announced in the next issue. The lectures for the most part will be given in the university halls, and invitation cards may be had from headquarters.

Correspondence on all matters pertaining to group centres should be addressed to Mr. J. J. Denton at head office.

Hastings Plaque.

Arrangements are being completed for the ceremony connected with unveiling the plaque in honour to Mr. Baird, which is to be erected by the town council, and unveiled by the Mayor of Hastings on November 7th at 4 p.m. The ceremony will take place in the Council Chamber of the Town Hall, Queen's Road, Hastings. It will be recalled that it was at Hastings that Mr. Baird performed his original experiments in 1924.

On the general question of the B.B.C. transmissions, Mondays to Fridays (11 to 11.30 a.m.), of the Baird system of television, the secretaries would be glad to know the feeling of members who may desire to secure better week-end facilities for receiving these signals. Such correspondence should be sent to Mr. Mitchell at head office, giving constructive suggestions if possible, and the nature of the experiments it is proposed to carry out.

J. J. DENTON, A.M.I.E.E.,
W. G. W. MITCHELL, B.Sc.,
Joint Secretaries.

Note to Correspondents

All letters should be addressed to the Editor, "Television," 26, Charing Cross Road, W.C.2. The Editor does not accept responsibility for any views expressed by correspondents, and he reserves the right to refrain from publishing any or part of letters received.

FORTHCOMING LECTURES

Lectures on television will be delivered at the following places by Mr. A. Dinsdale, A.M.I.R.E., Editor of TELEVISION, during November :—

Nov. 5th, 1929.—The Spalding Gentlemen's Society Hall, Broad Street, Spalding, Lincs., at 8 p.m.

Nov. 6th, 1929.—The Leeds Institute, Cookridge Street, Leeds, at 7.30 p.m.

Nov. 8th, 1929.—Philosophical Society, at 8 p.m., at the Watt Hall, Kelly Street, Greenock.

Nov. 9th, 1929.—Technical College Popular Lectures, at 7.30 p.m., at the Technical College, Abbey Road, Barrow-in-Furness.

Nov. 11th, 1929.—Abbey Foregate Literary Society, at 7.30 p.m., Working Men's Hall, The Square, Shrewsbury.

Nov. 20th, 1929.—Public Library, at 8 p.m., at the Carnegie Hall, Finkle Street, Workington.

Nov. 21st, 1929.—Literary and Scientific Society, at 7.30 p.m., at the Bath Assembly Room, Bath Avenue, Bath Road, Wolverhampton.

Nov. 27th, 1929.—Cheltenham College, Cheltenham, Glos., at 8.15 p.m.

Nov. 29th, 1929.—National Council of Women's Luncheon Club, at King's Head Hotel, High Street, Sheffield.

In most cases non-members of the societies concerned can gain admission to these lectures on payment of a small entrance fee at the door.

GOOD NEWS FOR LISTENERS.

The Radio Association, which was founded in 1922 and is by far the oldest listeners' organisation in this country, is to be entirely reorganised in order to be of the greatest possible benefit to listeners under present-day conditions. For this purpose the Council have appointed as General Secretary Mr. Ronald F. Tiltman, A.M.I.R.E., A.Rad.A., the author of several radio and television books, who until recently was Wireless Editor of *The Sphere*. Mr. Tiltman's name will be familiar to readers of this magazine.

The details of the national reorganisation scheme in hand are being kept a close secret at present, but it is said to be a very ambitious one, which will be revealed to the public before the end of the year.

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Some Impressions of the New York Radio Show, Sept. 23-29, 1929

By *Our New York Correspondent*

THE first and most striking impression which must be conveyed to an observer familiar with the amazing growth of the radio industry in America is one of disappointment. Figures convey little to the mind when they reach millions, but for what they are worth the following statistics show the huge size of this industry:

5,000,000 wireless sets are planned for production this year and at least 80,000,000 valves are planned;

18,000,000 American homes are stated to be equipped with telephones and 8,000,000 with wireless sets,

and the American radio trade slogan now appears to be: "Where there is a telephone there should be a radio."

Comparisons are often made between the automobile industry and the radio industry, and it is now the proud boast of the leaders of the radio industry that the "radio dollar is now almost equal to the automobile dollar," meaning that almost as much money is spent by the American public on radio as on automobiles.

Most people in Great Britain have some idea of the motor show at Olympia and, recalling how much greater is the American motor industry, would imagine that the American radio show at New York is a much greater and more glorified Olympia. But this is not so, and this show is no more imposing than the radio show held in London. In spite of this there has been a record attendance, and exhibitors report that sales have been made totalling about $31,000,000. 306,000 visitors passed through the turnstiles, and merchandise to the value of $1,000,000 was exhibited at 1,500 booths at the show. $300,000 was spent on actual broadcasting from the "Crystal Studio" in the show.

Keen Interest in Television.

One of the leading New York radio journalists last year made very careful and extensive inquiries of visitors to the radio show, as to what they came to see at the show. The result of this census was that, first and foremost, 85 per cent. came to see television. It was generally known before the show opened that the only television exhibited at the forthcoming show would not be very different from that of last year, and the writer discussed with this authority before the show opened what would be the chief attractions this year.

The conclusions we came to were that the television theatre would still be the centre of interest, but that its drawing power would be divided with Nikola Tesla's huge coil in operation and the Crystal

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broadcasting studio where celebrities could be seen making public broadcasts. Judging by the crowds around the various booths, this forecast appeared to be correct, except that the interest in television was not so much in television itself but in the various celebrities of stage, screen, politics, sport and public life who could be seen and heard at the television theatre daily on a regular schedule.

The television exhibit in question was staged by the General Electric Co. This, in the writer's opinion, was not of such good quality as the one they gave last year, although the brilliance of the image was very much greater, and it was projected upon a ground glass screen in place of the silver screen used last year. Detail, however, was not by any means so good, the whole image having the appearance of being out of focus, possibly due to the use of poor quality lenses in the receiving disc, which, it is understood, was of the 60-line type. The source of illumination was apparently a Moore crater lamp such as was used last year.

Huge Cells Employed.

In the matter of subjects scanned nothing more ambitious than head and shoulders was attempted, and the reproduced image was almost exactly life-size. Synchronism was attained by means of synchronous motors and the television signal was transmitted over lines. The photo-electric cell equipment was quite extensive, consisting of four extremely large cells arranged at the corners of a square whose diagonal was vertical. These cells were approximately ten inches in diameter and of spherical form. The power of illumination used at the transmitter was very much less this year and appeared to be provided by approximately a 1,500 to 2,000 watt projector lamp. Gears at the transmitter have been abolished, the disc being directly driven from the motor spindle.

One improvement this year has been made in the receiver, in that it is now contained in a single box with its associated screen, instead of having the screen separate and at a distance of some ten feet from the main box. This improvement was apparently accomplished with the aid of a system of mirrors placed within a cabinet and so arranged as to give the desired length of path between disc and screen without the use of ultra short-focus lenses. In other respects the apparatus appeared to be entirely unchanged.

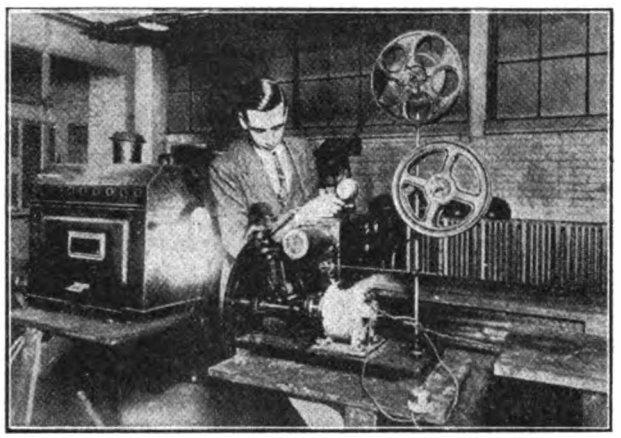
There is no doubt that the exhibit this year was below the standard of last year, although dual transmission was made, and it seemed to be the studied policy of the General Electric Co. to create that impression. This opinion has been confirmed from other sources.

Another impression of the show was the astounding amount of literature distributed. Towards evening one had literally to wade ankle deep through paper. Of course, every trade show has its story, and the story which was going the rounds of the American show was that an unfortunate visitor was arrested in Eighth Avenue because, when going through the show, he was forced to take pamphlets, journals and newspapers almost at every step so that the action became automatic, and when he got out into Eighth Avenue he started collecting newspapers from the news stands and was, in consequence, arrested for theft!

Important Innovations.

The most important innovations at the show were new valves, remote control devices, loud speakers, broadcasting and the "ether music" device. There did not seem to be as much development as was promised last year in combination phonograph and gramophone sets, or in home talking movies, although there were many exhibits similar to last year.

Two years ago the general idea of broadcasting in this country was that it was in rather a chaotic state



The cinema film transmitter of the Jenkins Television Corporation, New Jersey, U.S.A.

owing to interference produced by numerous stations and by the utilisation of time of broadcasting programmes for advertisement.

Recognising that the keystone of the whole radio industry is the broadcasting system, great efforts are being made here to effect improvements, and remarkable progress has been made. There are about 700 broadcasting stations in the United States, but in spite of this the result has ceased to be chaotic. Little or no interference is experienced in New York (where there are many broadcasting stations all broadcasting simultaneously) with the modern American all-electric wireless set, and the advertising matter, although in the writer's opinion undesirable, has ceased to be very objectionable; in fact, it is very often entertaining.

Organised Broadcasting.

One factor which has caused this is the formation of networks or chains of broadcasting stations extending from coast to coast, and north and south, which broadcast about 40 to 50 per cent. of a programme simultaneously. The two largest of these are the Columbia Broadcasting Co. and the National Broadcasting Co., which latter is associated with the Radio Corporation. Although continually threatened that they are illegal, in that they form a trust, and that

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they utilise "ether space" which is intended for other uses, the National Broadcasting Co. is developing rapidly, and in the opinion of the writer has largely contributed to the great technical improvement as regards purity of transmissions and the provision of suitable and varied programmes.

It must be remembered that the broadcasting stations are on the air for much longer hours daily than are the B.B.C. stations in England. The three chief stations in New York average seventeen hours daily, beginning with the "Daily Dozen" about 7 a.m., and finishing with slumber music, dance music or the "Dreamers" after midnight. One wonders what would happen if the hard-worked staffs of the B.B.C. stations were occupied to the same extent and were then asked to provide time for television experiments. . . .

One other noticeable advance technically is the wonderful improvement that has been made during the past year in long distance transmissions. Paul Whiteman's Band has been playing regularly at Hollywood, four to five thousand miles away from New York, during the past summer for an hour each week. Part of this transmission to New York was undoubtedly over a line, but the reception was remarkably pure, static very rarely interfering.

Recently, Maurice Chevalier, speaking on the telephone in Paris, was re-broadcast in New York with exactly the clarity of a broadcast from a New York studio. It bore no resemblance to the awful re-broadcasts from America heard in England, or those from England heard in America a year ago. There is no doubt that next year remarkable improvements will be made in broadcasting, and really very excellent reproductions of regular programmes from Europe will be heard as part of the daily programme from some of the American stations.

How Television Stands Commercially.

After all the flurry and publicity over television in America at this time last year, the past year has been one of comparative quietude and almost slump. Several factors have contributed to this. The radio industry of America is not as a whole now interested in catering to the enthusiastic amateur, and so, when the question of television was discussed from a commercial point of view, the industry was chiefly concerned in the quantity production of televisors or in radio sets incorporating televisors. Consequently no commercial development of any magnitude resulted at this stage, as it was not considered that the state of development of television was such that it would entertain and maintain the interest of the man of the street, although it would have been readily welcomed by enthusiasts and amateurs. Several firms of minor importance made kits, parts, and rather crude televisors, but most, if not all, of these have now ceased.

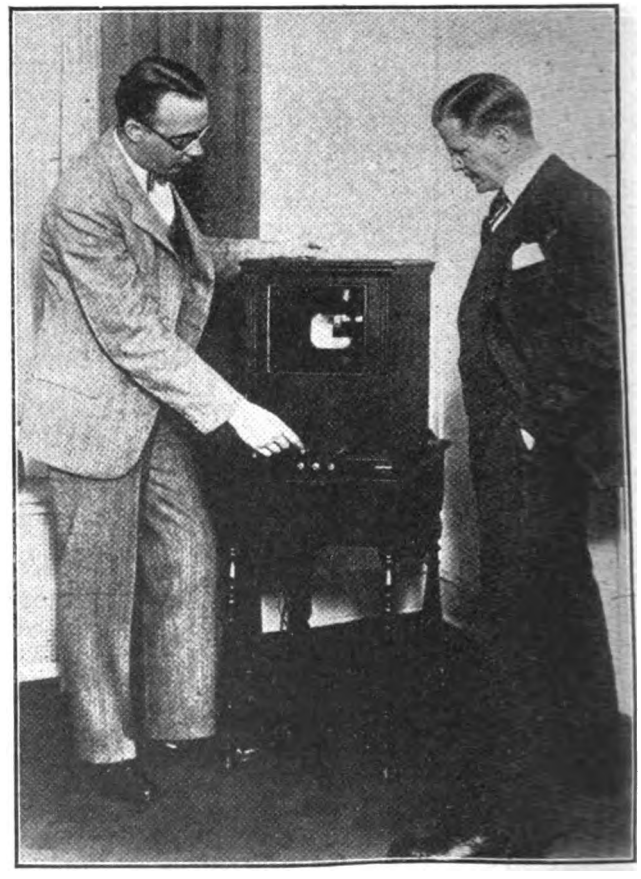
Those firms who are most interested, such as the Baird Television Corporation, the Radio Corporation of America, and the Jenkins Television Corporation, while steadily improving their apparatus, saw the early prospect of improvement, and hesitated to make plans for large scale manufacturing.

Last year the huge capital of the radio industry worked itself into a very nervous state at the thought that the buying public was "holding off" because there was something new—that is, a television attachment to the set—being produced immediately. Much publicity was, therefore, given to the statement that television was not yet a commercial fact, the Radio Manufacturers' Association issuing a public warning against the buying of any television apparatus for this reason.

Wavelength Allocations.

Last year permits for experimental television broadcasting on the normal broadcast waveband were issued by the Federal Radio Commission, and a number of experimenters started broadcasting. Many of them were inexperienced, and did not realise the damage they were doing to the development of the science. This damage was caused by broadcasting over an exceedingly wide frequency band, using a large number of holes in their scanning discs, and speeding up their motors to avoid flicker.

The belief gradually grew that listeners would be disgusted by the irritating image sound issuing from their loud speakers to the exclusion of the regular broadcast programmes, if television were permitted on this broadcast band. In the end the Federal Radio Commission issued a peremptory order in January



A television receiver, employing drum scanning, as produced by the Jenkins Television Corporation.

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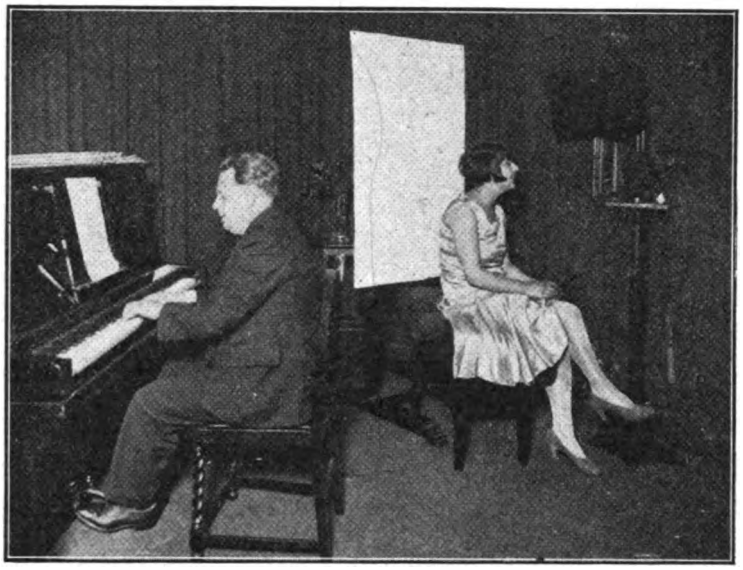
last that no further television on the broadcast waveband would be permitted.

To replace this they have since issued a limited number of permits for experimental television on wavelengths between 100 and 150 meters. This militated against the commercial development of television, in that although radio sets covering the band 200 to 600 meters had been developed to such a state of perfection, shorter wave sets had not been developed to the same extent. In addition, the well known drawbacks of short wave reception, " fading," " skip distance," and difficulty of control in unskilled hands, tended further to stop commercial developments. It is not realised in America even now that television can be transmitted within the limits allowed for ordinary speech broadcast, and yet provide suitable variety of subjects to interest and entertain the public.

Jenkins Television Corporation.

Only one firm has made a definite announcement of commercial development on any scale, and that is the Jenkins Television Corporation, who are building large factories in New Jersey and erecting broadcasting stations with lavish expenditure. They state that they will produce television sets for receiving broadcast films in silhouette and in half-tones, and crude television images. As they have been granted a permit over a band of 100 kilocycles, if their apparatus is suitable they should be able to transmit a very large variety of subjects.



Miss Lulu Stanley seated before the television transmitter in the Baird Studio on the occasion of the inaugural broadcast through 2LO on September 30th.

The Radio Corporation of America are reported to have set aside a large sum of money to develop television. They have erected a broadcasting station for this purpose in New York, and have permits for other stations. They regularly transmit for experimental purposes daily from 7 to 11 p.m., and the frequency band they use is about 80 kilocycles. Their officials, however, have repeatedly stated that television is still in the experimental stage and is not yet ready for commercial development.

The Baird Television Corporation, in the meantime, have been developing the Baird system in conjunction with developments taking place in England. In addition, they have been replacing the British apparatus used in the system with American materials, adapting the system to American conditions, such as the universally used 110 volt A.C. mains, and developing methods of automatic synchronism and methods of projection.

Perhaps the best idea of the situation in America can be gathered from the public statements recently made by men well known in the industry.

Public Statements.

Dr. A. N. Goldsmith, who is in charge of television development for the Radio Corporation of America, declares that radio television is at present " an experimental project in its experimental stage." This is understood to reflect the attitude of the Westinghouse Company and the General Electric Co. with whom the Radio Corporation of America are allied.

Mr. F. B. Jewett, President of the Bell Telephone Laboratories, and Vice-President of the American Telephone and Telegraph Co., said: " While we still believe in the ultimate practical value of television, we have as yet no programme for its public use."

Mr. D. E. Replogle, Chairman of the Television Committee of the Radio Manufacturers' Association, said: " That television will require distinct and new receivers, separate from the broadcast receiving set, is now assured from progress being made in laboratories and in other television experiments. Present radio receivers, even if television broadcasting was permitted in the sound broadcast band, would not be adequate or suitable for picture reception.

" For economic and technical reasons it has been found best to place television broadcasting between the wavelengths of 100 and 150 meters, to which none of the commercial receivers now on the market will adequately tune. A television receiver must be very different in electrical design from that used for sound reception. One conclusion drawn from this is that television will require distinct and new receivers, and that a so-called television attachment is meaningless. This is of interest to the radio public. It does not mean that present radio sets will become obsolete, but it does mean that there will be a television receiver —distinct and separate—which will work in conjunction with a broadcast receiver for dual reception of sight and sound. The trend is for the television receiver, amplifier and scanning mechanism to be in one cabinet."

Capt. Jarrard, of the Baird Television Corporation, states " that television subjects are being broadcast in Europe of sufficient interest and variety to interest the general public, confined within the frequency band allowed by the broadcast authorities, that is, 10 kilocycles, on the usual broadcast frequency band."

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The Chemistry of Electrical Storage

By *W. F. F. Shearcroft*, B.Sc., A.I.C.

(Fellow of the Television Society)

IT is one of the characteristics of a chemical reaction that it is accompanied by some change of energy, which is manifested in a manner we can easily detect. In fact it is this energy change which commonly attracts our attention. We consider the *heat* given out by a fire more than the chemical action which is concerned with the union of the coal with the oxygen of the air. The *explosion* of a cartridge attracts our attention more than the chemical action taking place among the contents of the cartridge.

Energy we recognise in many forms, the distinction between which appears to be not so much differences of the energy as differences of the means by which we detect it. Further, we know that one form of energy can be transformed into other forms with comparative ease. Thus, starting with the supply of energy we call heat given by the combustion of fuel, we can produce a corresponding supply of electricity, which in its turn can be transformed into light or back to heat. The loud-speaker transforms electrical energy into sound.

From a practical point of view the fundamental point is the production of energy. We are receiving continual streams of energy from the sun, of which we make very little direct use. For the artificial production of energy we depend almost exclusively upon the initial production of heat by some chemical reaction, and its subsequent transformation into other forms as required. (The use of water power is, of course, an exception to this.)

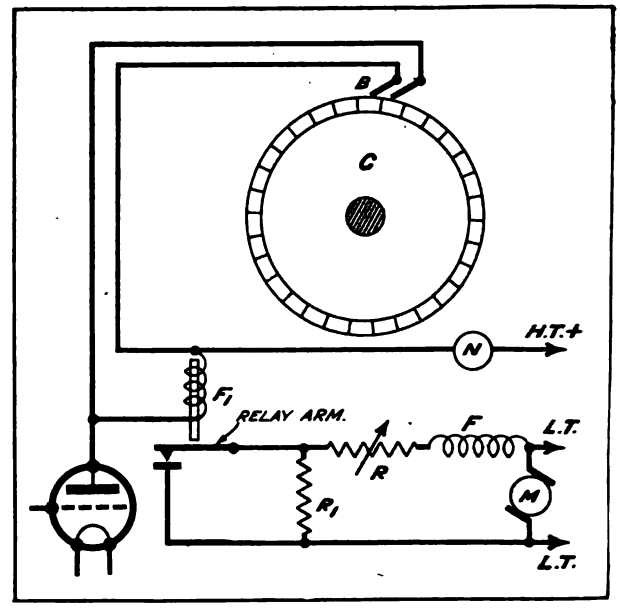
Chemical Reactions.

The energy produced during chemical reactions is usually in the form we recognise as heat. This, however, is not essential, for a chemical reaction can produce other forms of energy such as sound when the action is explosive; such as light when reaction takes place at a high temperature. Under certain conditions the energy is produced in the form of electricity.

All forms of primary batteries derive their electricity from the energy liberated when the chemicals within them undergo chemical changes. On open circuit there is ideally no chemical action. On closing the circuit the particular reaction of any particular cell commences and continues until all the chemicals present have completed the change. At first we may consider that there exists in the cell a certain system —made up of certain chemical substances.

This system contains a certain amount of energy. The chemical action which occurs on closed circuit converts this system into another one—consisting of different substances. The second system also contains a certain amount of energy, less than the former one. The difference has been liberated, and under the conditions arranged in the cell the liberated energy takes the form of electricity. When the transformation of the substances concerned is complete the liberation of energy ceases—the cell is run-down.

In any particular case it would be possible to take the substances remaining after exhaustion of the cell and, by more or less complicated chemical processes, re-convert them into the original substances, and thus start the cell over and over again. Part of the necessary chemical operations would entail the supply



RELAY SYNCHRONISING SYSTEM.

We regret that an error crept into the diagram marked Fig. 1 on page 396 of our October issue. The corrected drawing is reproduced above.

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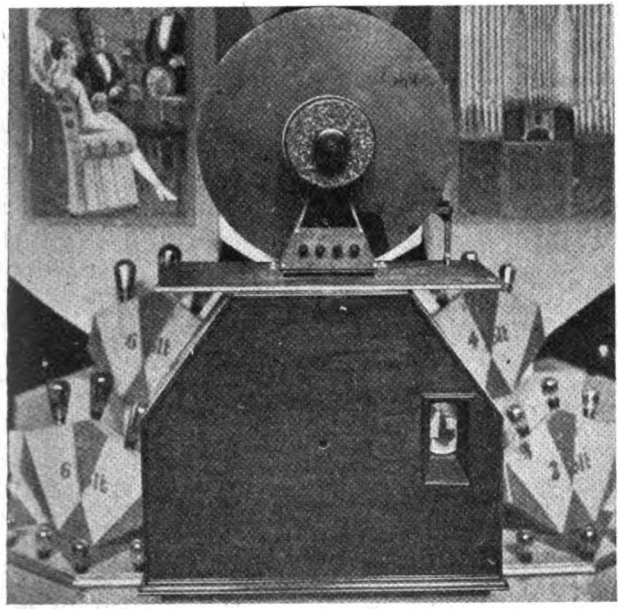
of an equivalent amount of energy to that given out as electricity while the cell was working. Such "regeneration" of a cell is not, however, a practical process. The addition of the necessary energy would entail too complicated operations to make it economically sound.

There are, however, certain chemical actions which are reversible under special conditions. These take place in one direction when subjected to electrical influences, and occur in the reverse direction when allowed to act like a primary cell and give a supply of electricity.

On such reactions is based the theory and practice of secondary batteries, although it must be admitted



A Baird Televisor Receiver (removed from its case) on the G.E.C. Stand at Olympia.

that practice is a little in advance of theory. There are numerous chemical systems which in this way can receive a charge of electricity, transform it into chemical energy, store it up indefinitely, and reproduce it as electricity when required. Two only have any practical importance to-day, but it would be idle to suppose that the last word has been said on the subject.

The commonest storage battery or accumulator is the lead accumulator. Here the chemical system consists of a suitably arranged grouping of lead peroxide (PbO_2), sulphuric acid (H_2SO_4), and metallic lead (Pb). This system is in a condition necessary for the production of electrical energy, which is liberated as a steady current when the peroxide supply is connected by a conductor to the lead, both lead and peroxide being contained in a dilute solution of sulphuric acid.

While the current is being liberated the lead dioxide, which is the positive plate, is reduced to lead sulphate ($PbSO_4$), and the metallic lead is oxidised to lead sulphate also. This we may represent in formulæ thus:—

$$PbO_2+2\,H_2SO_4+Pb \longrightarrow 2\,PbSO_4+2\,H_2O.$$

If now a current of electricity be supplied through the cell, then the reverse action takes place, resulting in the reformation of the lead dioxide and the metallic lead. The sulphuric acid, which during the discharging process has become more and more dilute, also regains its original concentration. The whole action may be summarised thus:—

$$PbO_2+2\,H_2SO_4+Pb \underset{\text{charge}}{\overset{\text{discharge}}{\rightleftharpoons}} 2\,PbSO_4+2\,H_2O.$$

This explanation of the action of the lead accumulator is known as the *double sulphate* theory. It has been assailed by more than one worker, and there still remain points which it fails to explain. General opinion considers that it is essentially the true explanation.

The lead accumulator is an efficient instrument. It is certainly handicapped by the weight of the plates on which the oxide is pasted and the negative plate, and by the fact that these plates are not mechanically strong. There is little or no chemical action while the cell is idle. This is very important as accumulators are designed to store up electrical energy over long periods, during which they may not be in action frequently. A very slight leakage may therefore become important. The cost of the lead accumulator is not great, and its resistance is fairly low, and with careful treatment it lasts a long time.

Less common than the lead accumulator is the iron accumulator, better known as the Edison Cell. The higher energy system consists of a positive plate of nikelic hydroxide ($Ni(OH)_3$), a negative plate of iron (Fe), in a concentrated solution of potassium hydroxide (KOH). While discharging the nikelic hydroxide is reduced to nikelous hydroxide ($Ni(OH)_2$), and the iron is converted into ferrous hydroxide ($Fe(OH)_2$). The reverse reaction takes place when the cell is charged.

We may summarise this action thus:—

$$Fe+2\,Ni(OH)_3 \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} Fe(OH)_2+2\,Ni(OH)_2.$$

During charge and discharge there is very little alteration in the concentration of the potassium hydroxide solution. Although the efficiency of the iron accumulator is not so high as that of the lead, it possesses certain advantages. As at present constructed, it is very durable and will stand severe jolting. Its high initial cost is balanced by its long life. A serious disadvantage is the higher loss which takes place during both charging and discharging.

The efficiency of these two cells may be compared in the following table:—

—	Ampere-hour efficiency.	Watt-hour efficiency.
Lead accumulator ..	95%	75–85%
Iron accumulator ..	82%	59%

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Characteristics of Selenium Cells

Some Experiments With Coloured Light

By *Cyril Sylvester*, A.M.I.E.E., A.M.I.Mech.E.

A CONSIDERABLE amount of matter has been written about selenium, and its more or less erratic sensitiveness to various intensities of light. Very little, however, has been written about the characteristics of selenium when subjected to the influence of coloured light. I have recently carried out some experiments on selenium cells of various capacities with coloured light as an exciting medium. For experimental purposes I have at my disposal a large photometer room in one of the London Technical Colleges; this is ideal for carrying out such experiments, since the walls are painted dead black so that direct reflections and cross reflections from walls are eliminated.

Getting Reliable Data.

At first thought it may be questioned why the effect of coloured light upon selenium should be of interest to experimenters in television. On consideration, however, the opinion will be formed that such experiments are the only ones from which reliable data can be derived, data which will assist the experimenter in knowing the possibilities or potentialities of selenium as a light-detecting medium.

In a recent series of articles on "Light—The Essential of Television" I pointed out that all objects are seen by the light which is reflected from them. But this does not refer to white light alone; coloured objects are seen merely because they reflect "coloured light"; green objects reflect green light, red objects red light, and so on; the remainder of the colours in the spectrum are absorbed. If, therefore, a selenium light-sensitive cell is to be used for experimental purposes its responsive characteristics to coloured light should be known. This is more clear when it is remembered that, in a scene to be broadcast, very few of the objects are white, so that very little white light is reflected.

The chief characteristic of selenium is that, under the influence of light of various intensities, its electrical resistance is a variable quantity. With high intensities of light its resistance is less than when subjected to light rays of low intensity. The reflection factors of coloured objects varies from zero (almost black) to cream or ivory (almost white), that is, from 0 to approximately 85 per cent. of the white light received by the objects.

From this a little reasoning will show that objects with various reflection factors can be referred to as light sources of various intensities. That is, with a constant white light source, the intensity of light reflected from a coloured object will depend upon the reflection factor of that object. In other words, an object with a reflection factor of 80 per cent. will reflect light having twice the intensity of that from an object with a 40 per cent. reflection factor.

For experimental purposes it is impossible, in an ordinary scene, to separate the light rays of various intensities which are reflected from various objects. I therefore obtained, for the purpose of my experiments, colour screens of which the "absorbtion factor" was known. This absorbtion factor can be interpreted in terms of reflection factor, assuming an efficiency of 100 per cent.

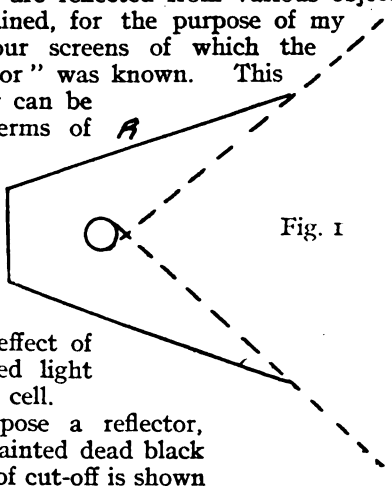

Fig. 1

The preliminary experiments consisted of determining the effect of direct and diffused light upon a selenium cell.

For this purpose a reflector, *R* (Fig. 1), was painted dead black inside; the angle of cut-off is shown by the dotted lines. The cell was connected up to very sensitive measuring instruments (the detecting medium was a shunted reflecting galvanometer and an optical system by means of which a deflection of 1/1000 mm.

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could be seen) and the lamp was a gas-filled lamp run on twice its rated voltage; this to ensure that the light rays were of an instantaneous intensity value. The lamp was connected to a flasher (motor driven) which gave intermittent flashes of a half-second with twenty-second rest periods. The intensity of light was nearly 50 foot-candles, and the quality of light approximated closely to daylight.

With the first flash of light the deflection moved from zero to 350 degrees; during the dark period the deflection did not drop to zero but, for approximately 20 flashes, it was maintained at 15 degrees. The maximum deflection during each flash was maintained for 12 flashes. When it commenced to fall a 320 degree value was reached and maintained. The minimum deflection, however, was increased to 45 degrees. I found that with a reversing switch which passed current through the cell in the opposite direction, the minimum deflection could be considerably reduced.

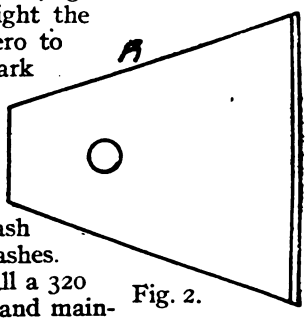

Fig. 2.

I then fitted a diffusing glass screen over the front of the reflector as illustrated in Fig. 2. This resulted in dispersing the light rays in all directions, so that there was no definite angle of cut-off between the lamp filament and the reflector edge; the general result was that the intensity of light was decreased. I then proceeded as before, but with a new selenium cell. The maximum deflection was 300 degrees, with a minimum time lag of 40 degrees. These figures will serve to show that, with white light (either direct or diffused light rays), the excitation of a selenium cell is not proportional to the intensity of light received by it, and this may be for the following reasons.

When a cell is first excited the current rises from a zero value, but does not drop to zero when the light source is extinguished. The micro-structure of the material may be such that the molecules are altered in shape and position with the passage of electric current; this is a common feature of tungsten, such as is used in the construction of the filament of a modern gas-filled lamp. One thing is evident, however, and this is that the molecules appear to set, or adhere, together with more electrical contact on the higher intensities of light.

The Use of Filters.

With regard to the excitation of selenium cells when under the influence of coloured light, I carried out experiments with four colour filters which were placed over the front of the reflector previously described. The colours were the most popular ones —red, blue, green and yellow. Each colour was tested on a new cell, or at least one which had not been excited for some time.

Red.—The light absorbtion of the red colour filter was about 40 per cent. The maximum deflection was 280 degrees and the minimum lag 24 degrees. This shows a higher efficiency than when white light alone was used.

Blue.—The light absorbtion of this filter was approximately 50 per cent. The maximum deflection was 290 degrees and the minimum lag 22 degrees. This result is interesting because, although the intensity of light was decreased, the maximum deflection was increased (when comparisons are made with the results obtained with the red filter) and the minimum lag was decreased. That is, the efficiency is higher.

Green.—This was rather a dark green with an absorbtion of 45 per cent. The maximum deflection was 285 degrees with a time lag of 24 degrees. This is almost proportional to the results obtained with the blue colour filter.

Yellow.—The absorbtion here was 25 per cent. The maximum deflection was 300 degrees with a time lag of 38 degrees. Although the absorbtion was lower than in the case of the other colour filters, it must be remembered that the intensity of yellow light is higher than any of the other colours in the spectrum; this accounts for the higher efficiency results.

Using Two Reflectors.

I then carried out some experiments with the projection of coloured light from two reflectors upon one cell. I tried together red and blue, blue and green, green and red, and red and yellow. The total absorption in each case was, of course, different so that different results were obtained. Consideration of these results, however, with those obtained by the use of separate colours showed that they were directly proportional to the latter.

It will be seen that with both white and coloured light an inherent characteristic of selenium is that it has a variable time lag, the latter depending upon the intensity of the light with which it is excited. The results I obtained by passing current through a cell in the opposite direction (to bring the molecules back to zero) gave me a certain amount of encouragement to proceed further along these lines.

I connected a condenser in parallel with a cell and, by means of a reversing switch connected to the flasher, passed a reverse current through the cell. The capacity of the condenser was such as to pass the same amount of current through the cell as was passing when the cell was excited. This, of course, had to be done during the dark periods, so that the increased resistance value of the cell had to be taken into consideration. The result was that I succeeded in reducing the time lag with a blue filter to 7 degrees. This is certainly a step in the right direction, and should encourage experimenters to obtain better results.

As a result of the experiments I have carried out I am convinced that there is a great future for selenium as a light-sensitive cell. I will be pleased to hear of further experiments carried out by readers in connection with these cells.

ANNOUNCEMENT.

We desire to bring to the attention of Australian readers the fact that Messrs. McGILL'S AGENCY, Elizabeth Street, Melbourne, *stock all our publications.*

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The Figh

By *W. Barrie Abbott*, B.L., C.A.

John L. Baird.

OF all the unpatriotic actions that have been done by so-called friends of their country, few can be so glaring as the attempt of vested interests and wounded *amour propre* in Britain to hold up British television, or at least to delay it in the hope that some foreign system will displace it. For a long time now, and right up to the present moment, British television has been, and still is, synonymous with Baird television, because there is no other British system in existence. *The fight against Baird television is therefore indisputably against British television.*

Unwarranted Antagonism.

Instead of welcoming and encouraging this marvellous British invention, the wireless authorities in this country appear to have done their utmost to belittle and discourage it; and even at this date, when impartial observers give glowing testimony to the clear-cut results shown in recent demonstrations, we have men of Captain Eckersley's standing in the wireless world solemnly telling his readers that British television is "merely a mechanical toy."

It is interesting to analyse some of the statements contained in Captain Eckersley's article on television appearing in a recent issue of *Popular Wireless*. He says: "I have never attempted to disguise my firm belief that wireless broadcasting has nothing to do with image sending"; and in the same week in *Amateur Wireless*, we have Dr. Gradenwitz writing about the German Wireless Exhibition, stating that "undoubtedly the great sensation of the show was television. . . . Television in Germany may be said to have been definitely adopted as a valuable adjunct to ordinary acoustic broadcasting."

In Germany, the British system has been acknowledged and taken up by the Government purely on its merits. Later in his article, Captain Eckersley asks whether the B.B.C. "should take up the time of its real public in catering for those who wish to play with a scientific toy, which is incapable of a service application or of further development on existing lines." This reminds me of the man who would not allow his son access to any musical instrument and then blamed him for not being able to play!

Attitude of B.B.C.

Unless one knows all about television, one is not in a position to say anything authoritative about its possibilities of development; and if the B.B.C. deny British television the necessary facilities to ensure success—facilities which they could give, if they merely had the will to do so—surely they or their officials should be the last people to blame the system for not producing results. Baird has demonstrated conclusively that with the small ration of ether given him he can produce small television pictures in clear-cut detail, but if the B.B.C. refuse to grant the necessary wave-lengths for other performances which British television can produce, it is not for them to try and gull the public into believing that the fault is other than their own. This is how the B.B.C. are behaving.

Vision Without Speech.

After considerable pressure by the Postmaster-General, they grant experimental facilities; but by granting only one wave-length they prevent the simultaneous transmission of vision and speech, the reason given being that they *cannot spare* two wave-lengths, and a "patriotic" writer in *Popular Wireless* points out that possibly in a year's time the necessary two wave-lengths may be given! Do the B.B.C. offer to cut out some of the unwanted programmes and give British television a fair chance to show what it can do? No, but instead of this, the ex-chief engineer writes his article in *Popular Wireless* contradicting in theory the very performance being carried out in fact at the Olympia Exhibition on the day before his article appears. And, as if to show his patriotic attitude, he produces photos of the German, American and Hungarian experimenters of television and gives no photo of the British inventor.

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or

British Television

Surely it can never be that his idea is to throw cold water on the British system, to delay its operation in the hope that a foreign system will bridge the gulf of superiority that at present exists between the British system and all others, and, above all, to prevent the too rapid development of the "radio-gramophone-television sets," which might render the purely radi-gramophone sets out of date. In his concluding sentences, Captain Eckersley says: "something ought to be done to stop this idea that the B.B.C. are holding up a great British invention. As I see it, they are in this case trying to uphold the rights and interests of the majority."

A Fair Chance.

I would suggest that the way to stop the holding up is for men like Captain Eckersley to press for British television being given a fair chance to show what it can do, and to cease "bolstering up" foreign experimenters. The contention that the majority of wireless listeners are not interested in this wonderful new science is not founded on fact.

Let us concede at once that the matter is full of difficulties. Hitherto acoustic broadcasting has had a monopoly of the ether and the existing authorities have "dug themselves in." But *seeing* by wireless is the natural corollary to *hearing* by wireless, and the wireless public do undoubtedly want to have both. British television claims that the band of frequencies required in the ether for successful television broadcasting is being narrowed, and it is for the B.B.C. to yield space for the development of television. Denying facilities will only injure British interests, play into the hands of unemployment, and continue our stupid policy of helping foreign countries at the expense of our own.

The Inaugural Broadcast.

As I write this article, on September 30th, the first day in the history of this country on which television is being broadcast, I cannot help observing that the B.B.C. refuse to offer two lines so as to admit of the simultaneous transmission of sound and vision. They do not seek to deny that British television can produce simultaneous transmissions, but they refuse to give it the chance, and, worse still, they deem the occasion to be of so little interest that in announcing the day's programme they cannot afford to devote even two or three lines to any special announcement of this epoch-making transmission! And yet the first letter in B.B.C. stands for British!

I write this article in no unfriendly spirit to the B.B.C. or anyone else, but rather as a plea to the British wireless authorities to change their attitude in the direction of befriending their own country.

* * *

In connection with the above, the following correspondence (copies of which have been sent to us by Mr. Barrie Abbott) speaks for itself:—

Sir John Reith.

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From Captain P. P. Eckersley to Mr. W. Barrie Abbott.

The British Broadcasting Corporation,
Savoy Hill, London, W.C.2.
October 3rd, 1929.

W. Barrie Abbott, B.L., C.A.,
Woodlee, Peebles.

DEAR SIR,—Thank you very much indeed for your letter and for your courtesy in showing me the article that you propose to write. I do assure you that you have got hold of the wrong end of the stick. The point is this and only this: There is a fundamental disadvantage in television, that it takes up so wide a spectrum of the ether. With broadcasting we cannot use more than 20 k.c. total width of band because we cannot technically, and we have agreed not to internationally. Now with 10 k.c. side-band it is impossible to produce a picture which is worth looking at. The only result that can be made must be made in terms of the expansion of the side-band. It might interest you to know that at a recent conference 100 k.c. was proposed as a quite ordinary band for television, that would mean to say that one television transmitter would take up the room now occupied by ten stations and it is not possible on the broadcasting wavelengths to do better than has been done to-day. I do not say that if the television people get hold of their own station and use a short wave that very much better results could not be obtained; all I say is that it is a fundamental technical fact that 10 k.c. side-band is not good enough to give a service basis to what is transmitted and received.

Why should I be against Baird or against anybody? What possible axe have I to grind as chief engineer here? Do you not think on the lowest terms that I would welcome an enormous addition to our service I ought to be the first person to welcome a new adaptation of broadcasting as it adds to the importance of the service for which I was responsible. You accuse me; in fact, of the most appalling immorality (in the proper sense of the word) in that I am simply attacking somebody for the sake of attacking him. I am trying, in a world which fails ever to talk about facts, to base my arguments on facts, only facts, and nothing but facts, and the facts of the situation are that with a broadcasting station it is impossible to give worth-while television.

Many thanks for writing and for the article and many thanks for your interest, but do please believe that my attitude is perfectly sincere and is based on facts.

Yours very truly,

(Sgd.) P. P. ECKERSLEY.

From Sir John Reith to Mr. W. Barrie Abbott.

The British Broadcasting Corporation,
Savoy Hill, W.C.2.
12*th October*, 1929.

W. Barrie Abbott, Esq., B.L., C.A.,
Woodlee, Peebles.

DEAR SIR,—I beg to acknowledge receipt of your letter of the 3rd, enclosing a copy of an article entitled "The Fight against British Television," written by you. Your accusations against this Corporation are quite unwarranted, but as it is apparent that you are labouring under a misapprehension, I will endeavour to remove it to some extent.

Firstly, there has never been, nor is, any antagonism on the part of the Corporation towards inventions such as Baird television.

Secondly, the number of ether channels available in this country is strictly limited by international agreement. Each channel is a specified width and includes a band of radio frequencies outside which the transmitter must not radiate. This width is just sufficient for music and speech, but the width of the band required for high quality television is much greater. Since practically all European broadcasting stations have agreed not to transmit outside their allotted band of frequencies, the designers of television transmitters have restricted themselves to these comparatively narrow bands. The definition and steadiness of the picture leaves much to be desired, and provides a result of doubtful interest. There are other difficulties, but the above is fundamental to all systems.

Thirdly, the B.B.C. is of the opinion that the technique is not yet sufficiently advanced to allow television to supplant normal programmes, which appeal to an infinitely greater number. The Corporation is responsible for providing a broadcasting service to millions of listeners, and the ordinary service must take priority over experimental transmissions of any kind, unless the interests of the great majority are to be prejudiced.

Experimental transmissions of television are in progress, as you know. If and when the process improves sufficiently to be considered in terms of a service adjunct to ordinary programmes, the matter will naturally be carefully considered. At the moment, it would be unreasonable to occupy two separate ether channels in order to include sound accompaniment until it is proved that the type and quality of the pictures transmitted justify it from all points of view.

Yours faithfully,

(Sgd.) J. E. W. REITH.

From Mr. W. Barrie Abbott to Sir John Reith.

October 16*th*, 1929.

Sir John Reith, Director-General,
The British Broadcasting Corporation,
Savoy Hill, W.C.2.

TELEVISION.

DEAR SIR,—I thank you for your letter of the 12th inst., and for your courtesy in replying at such length. I am glad to have your assurance that the B.B.C. has no antagonism towards British television, and I would sincerely hope that this assurance will soon be followed by deeds.

I agree that the width band is a difficulty, but surely that does not justify indiscreet statements by the chief engineer of the B.B.C. to the effect that British television is a mere toy, etc. Whether the quality of television sent through the existing wave band is worth while or not, seems to me to be a question for the *public* to judge, and nothing should be done to prevent the public from getting a fair opportunity to do so. For anyone to suggest that the 10 k.c. band is a stone wall barrier against improvement is monstrous. It is this attitude that British television has had to face all along. Always it has been: "Yes, they have got so far, but they can go no further."

I am glad to see from authoritative reports that the experimental transmissions are proving a success and have revealed the interesting fact that large numbers of amateur enthusiasts have already built receiving sets that are obtaining excellent results. It is undoubtedly the case that the public want television, and I do hope that the B.B.C. will do all they can to satisfy that natural and legitimate demand at the earliest possible date.

Again thanking your for your letter,

I am, yours faithfully,

(Sgd.) W. BARRIE ABBOTT.

Mr. W. Barrie Abbott to Capt. P. P. Eckersley.

16*th October*, 1929.

Captain P. P. Eckersley,
British Broadcasting Corporation, London.

DEAR SIR,—Many thanks for your letter of the 3rd inst., and your courtesy in replying at such length. Even if one concedes your point about the width band—and other technicians refute it—that does not seem to justify your writing in the unfriendly strain which you have indisputably adopted in the past towards British television. Why couldn't you say something like this: "Television is a wonderful thing, and there is evidence to show that British television is far ahead of any other system. There is still one difficulty

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to overcome, however, namely, the narrowing of the width band. It is hoped to solve this soon, and I am willing to help to solve it and to establish regular broadcasting of British television in this country." Would not that be more like the expression of a patriot? You know it would.

You say: "It is a fundamental technical fact that 10 k.c. side-band is not good enough to give a service basis to what is transmitted and received. In this you differ from technicians whose abilities are at least equal to your own, for example, Sir Ambrose Fleming, the inventor of the thermionic valve. Sir Ambrose has publicly refuted the dogmatic assertions of those who have attempted to calculate the limitations of television on half-tone basis.

You further say: "The facts of the situation are that with a broadcasting station it is impossible to give worthwhile television," and you claim to base your arguments on "facts, only facts and nothing but facts." This sounds well, but are your facts true? The evidence is all to the contrary, and this high-sounding claim on your part is one of those sweeping assertions of which you appear to be so fond, but which mature men of experience do not make, and which men occupying important public positions should not be allowed to make. Whether the quality of television sent through 10 k.c. band is worth while or not is for the *public* to judge. And you should do nothing to prevent the public from getting the opportunity to judge.

No one has a right to say that finality has been reached. British television can show a very satisfactory head and shoulder image, and for anyone to say that the 10 k.c. band is a stone wall barrier against improvement is monstrous. It is this attitude that British television has had to face all along. Always it has been, "Yes, they have got so far, but they can go no further."

You ask: "What possible axe have I to grind?" I do not suggest that you are grinding axes, but you will agree that your connection with the H.M.V. Gramophone Co. alone might, in the case of a weaker man, be a possible axe. I, for one, refuse to believe that you do not want to see radio-gramophone-television sets being sold in this country soon, but there is no doubt that the public are watching you closely to see any evidences of your trying to hold back what certainly would be detrimental to the sale of purely radio-gramophone sets.

I may add that your close connection with *Popular Wireless*, and the obviously antagonistic attitude of that journal to British television, shown by its continual "boosting" of foreign experimenters, is being freely commented on by wireless enthusiasts.

My article appeared in the *Glasgow News*, and copies have been sent, *inter alia*, to the B.B.C., Mr. J. L. Baird, the Lord Privy Seal, the President of the Board of Trade, Mrs. Philip Snowden, and Mr. Joseph Westwood, M.P.

I assure you that I have no personal feeling against you in this matter; my efforts are dictated solely by a strong conviction that a great injustice is being meted out to vital British interests. I would prize very much an assurance from you that, so far as in you lies, British television shall receive, if not every encouragement, then at least fair play.

Believe me, yours sincerely,

(Sgd.) W. BARRIE ABBOTT.

BAIRD "TELEVISORS."

In order to save time and unnecessary inconvenience, will those seeking information with regard to the Baird "Televisor" Receivers make application direct to the Baird Television Development Co., Ltd., at 133, Long Acre, London, W.C.2, (Telephone: Temple Bar 5401) and not to the offices of this magazine.

Television Broadcast by the B.B.C.

(*Concluded from page* 450).

11.12 a.m.—ANNOUNCER: "Professor Andrade will now be televised for two minutes."

11.14 a.m.—PROFESSOR E. N. DA C. ANDRADE: "I am glad to be able to take part in this interesting experiment, which may be compared with the occasion on which the records of the early phonograph were publicly tried. The voices that then issued from the horn were not of the clarity which we now expect, and the faces that you will see to-day, by Mr. Baird's ingenious aid, are pioneer faces, which will, no doubt, be surpassed in beauty and sharpness of outline as the technique of television is developed. One face, however, is as good as another for the purpose of to-day's demonstration, and I offer mine for public experiment in this first television broadcast."

ANNOUNCER: "Now we come to the second half of the proceedings which I fancy will be in a rather lighter vein."

11.16 a.m.—SYDNEY HOWARD. Televised for two mins.

11.18 a.m.—SYDNEY HOWARD. Gave a comedy monologue.

11.20 a.m.—MISS LULU STANLEY. Televised for two minutes.

11.22 a.m.—MISS LULU STANLEY. Sang "He's Tall and Dark and Handsome" and "Grandma's Proverbs."

11.24 a.m.—MISS C. KING. Televised for two minutes.

11.26 a.m.—MISS C. KING. Sang "Mighty Like a Rose."

11.28 a.m.—MAJOR A. G. CHURCH, M.P.: "This is the first official occasion on which the features of living persons have been transmitted through the British Broadcasting Corporation's station by arrangement with the Baird Television Development Company.

"It is a great occasion, and one on which it is a great privilege to be present. As the General Secretary of the Association of Scientific Workers I welcome this triumphant application of science to life. Mr. Baird's is a comparatively new invention. He does not assert that the images which you, who are in possession of televisor receivers see, are the final product of his brain, or those of other inventors interested in the development of this new means of communication. You yourselves will appreciate the nature of his triumph. You will not be satisfied until you can have transmitted to you visible images of activities in which so many of us are interested—for example, a classic horse race, the boat race, a football match, or a great public ceremony.

"We have heard recently a great deal about conversations across the Atlantic. The development of television will enable people not only to converse over great distances, but also to see each other at the same time. The influence this may have upon the relations between the heads of States throughout the world is incalculable. It must be beneficial.

"I desire to congratulate Mr. Baird warmly on the success which has attended his efforts. I should also like to express the hope that those who wish to see this new industry developed, and television must be regarded as a new industry, will, so soon as possible, instal a receiving apparatus in their homes."

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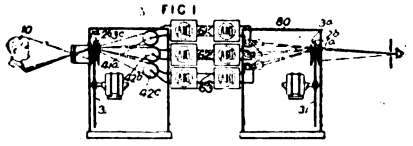
INVENTION *and* DEVELOPMENT

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. *each.*

Patent No. 315308 (Convention date, U.S.A., July 11th, 1928) granted to H. E. Ives: MULTIPLE SCANNING AND TRANSMITTING CHANNELS. — Three separate transmission channels, shown as 61, 62, 63 in Fig. 1, are fed by separate light-sensitive cells, 41A, 42B, 42C, through the action of a rotating disc 31. This disc carries groups of scanning elements for deflecting incident light beams, and each group co-operates with only one of the channels. Refracting or reflecting prisms 1A, 2B, 3C are arranged in such a way in spiral apertures in the disc that the light

FIG 1



beams from an object 10, incident on successive apertures, are deflected to the separate light-sensitive cells in rotation, and that light falls on each cell continuously.

The elements of the object transmitted over the different channels are thus interspersed.

Similar apparatus is used at the receiver 80, but modification of the arrangements allows for a large multiple element "bent-back" neon glow-lamp being used.

Patent No. 315859 (Convention date, Germany, July 21st, 1928), granted to D. von Mihály. SYNCHRONISING.—In a television receiver the picture reconsti-

FIG.2.

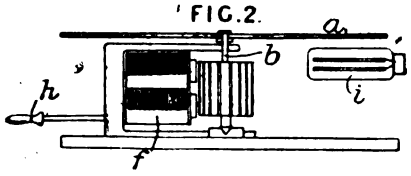
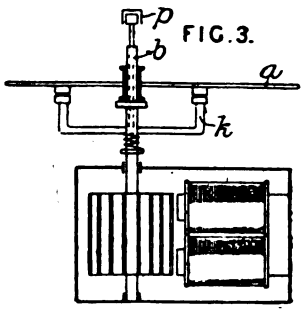


FIG.3.



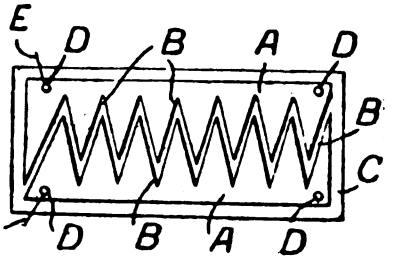


Fig. 4.

tuting disc *a*, Fig. 2, is driven by a phonic wheel on shaft *b*, the stator *f* of which can be rotated round the shaft *b*, as by a handle *h*, thereby bringing the disc *a* into synchronism with the transmitting disc. The glow-lamp *i* illuminates the holes in the disc *a* and forms the picture. The disc *a*, Fig. 3, coupled to a phonic wheel on shaft *b*, can be uncoupled by pressure on a rotating knob *p*, which lowers a coupling member *k*, and on

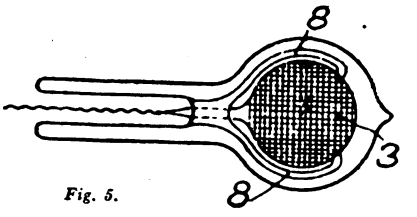


Fig. 5.

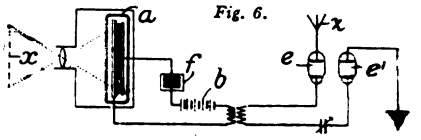
releasing knob *p* is re-coupled, thus enabling phase adjustment of the disc *a*.

Patent No. 317158, granted to J. Neale. —The electrodes *A* of a SELENIUM CELL (Fig. 4) are formed of thin sheet metal, preferably with interlacing spike-like fingers *B*. The electrodes are either embedded in insulating material *C*, such as bituminous compound, cellulose acetate, or a casein compound, or else sandwiched between a pair of insulating plates, one of which at least must be translucent and is preferably of glass. Rivets *D* may be provided for greater security and for the attachment of leads *E*.

Patent No. 317209, granted to G.E.C. and N. R. Campbell, describes a PHOTO-ELECTRIC CELL with auxiliary electrode such as a control or shielding electrode. This is composed mainly or entirely of a material such as carbon, which does not acquire photo-electric sensitivity readily from the metal forming the cathode of the cell, while *No.* 316937 (Convention date, Germany, August 6th, 1928, to Pressler) deals with means of preventing vibration of the anode of a photo-electric cell by using a second support. In Fig. 5 the anode 3 is shown mounted on a foot and steadied by one or more glass rods 8. In another arrangement an anode in the form of a loop, spiral, or grid is steadied by a strut secured to the envelope.

Patent No. 316340, granted to C. Ruzicka: TELEVISION WITHOUT SCANNING OR SYNCHRONISING.—Apparatus which is stated to transmit and

Fig. 6.



reproduce images of moving objects without scanning or synchronising comprises a transmitter, Fig. 6, and a receiver, Fig. 7. The transmitter consists of a light-sensitive cell *a*, packed with conducting granules such as thorium or barium, in a circuit supplied from a battery *b* or other source and containing a cell *f* stated to be a current-amplifying device. An image of the object *x* is thrown on one face of the cell *a*, and the transformed variations in the current are transmitted by valves *e*, e^1 from an antenna *z*, or by wire. The receiver consists of a cell *l*, Fig. 7, similar to the cell *a* and having a polished face which is flooded with light from a lamp *n*; the receiving circuit includes the aerial *z*, amplifying valve *k*, tuning devices *m*, and a current-amplifying cell *f*. The granules in the cells *a*, *l* may be replaced by a number of wires l^3, and other

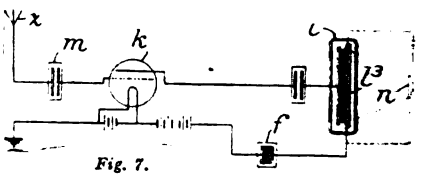


Fig. 7.

materials may be used instead of thorium or barium, such as uranium, chromium, calcium, boron, silicon, or strontium; or an alloy of two or more of these materials, with or without selenium, tellurium, phosphorus, copper, or silver. The amplifiers *f* contain granules or powder of a similar nature to those in the cells *a*, *l*, but preferably barium.

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Television

The Official Organ of the Television Society

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BAIRD TELEVISORS IN PRODUCTION

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THE WORLDS FIRST TELEVISION JOURNAL

THE TELEVISION SOCIETY

The Television Society was founded on September 7th, 1927.

The Society makes its appeal to those who desire to share in the responsibility of furthering this new branch of applied science.

THE OBJECTS OF THE SOCIETY

may be summarised as follows:

(*a*) The Study of Television and its application in applied science and industry.

(*b*) To afford a common meeting ground for professional and other workers interested in current research relating to Television and allied subjects and to afford facilities for the publication of reports and matters of interest to Members.

(*c*) To encourage the formation of *Local Centres* of the Society in the Provinces, so that by social intercourse and discussion among members these aims may be more fully realised.

The present register indicates a world-wide membership.

ORGANISATION

The Society consists of one Honorary Fellow, Fellows and Associates, and the management is vested in a Council of Fellows, including the President, three Vice-Presidents, and Ordinary Fellows.

FELLOWS.—Ordinary Fellows must be elected by the Council. Candidates for the Fellowship must be proposed by two Ordinary Fellows, the first proposer certifying his personal knowledge of the candidate.

ASSOCIATES.—Any person over 21 interested in Television may be eligible for the Associateship without technical qualifications, but must give some evidence of interest in the subject as shall satisfy the Committee.

STUDENT MEMBERS.—The Council have arranged for the entrance of persons under the age of 21 as Student Members.

SUBSCRIPTIONS.—The annual subscription for Ordinary Fellows is 20s., with an entrance fee of 10s. 6d.; and for Associates 10s., with an entrance fee of 5s.

The annual subscription for Student Members is 5s., entrance fee 2s. 6d.

LIFE MEMBERS.—Life Membership may be secured at a fee of £10 10s.

MEETINGS.—The ordinary meetings of the Society are held in London at the Engineers' Club, Coventry Street, W.1, at 8 p.m., on the first Tuesday of the month (October to May inclusive). Notices of meetings are posted to all members about seven days before the meeting

Full-size reproduction of the new Television Society Badge, which is available to accredited Members, and may be obtained from the Head Office, price 1s.

The official organ of the Society is "Television," published monthly by the Television Press, Ltd., 26, Charing Cross Road, W.C.2.

A memorandum for the guidance of members wishing to form a Local Centre of the Society may be obtained (gratis) on application to the Joint Hon Secretaries, 4, Duke Street, Adelphi, W.C. 2.

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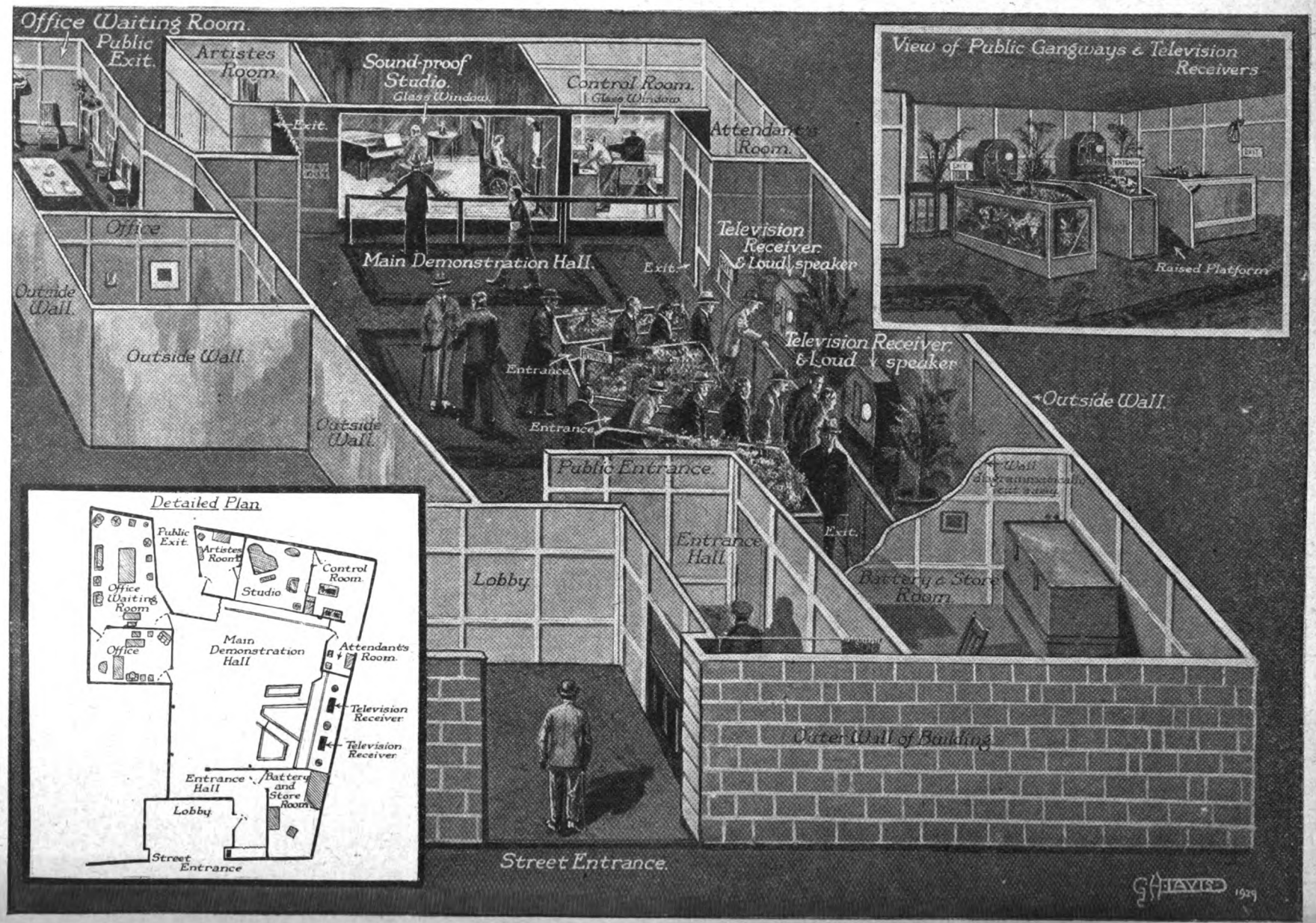

Pictorial representation of the premises in which television was publicly demonstrated during the National Radio Exhibition, Sept. 23rd to Oct. 3rd, 1929.

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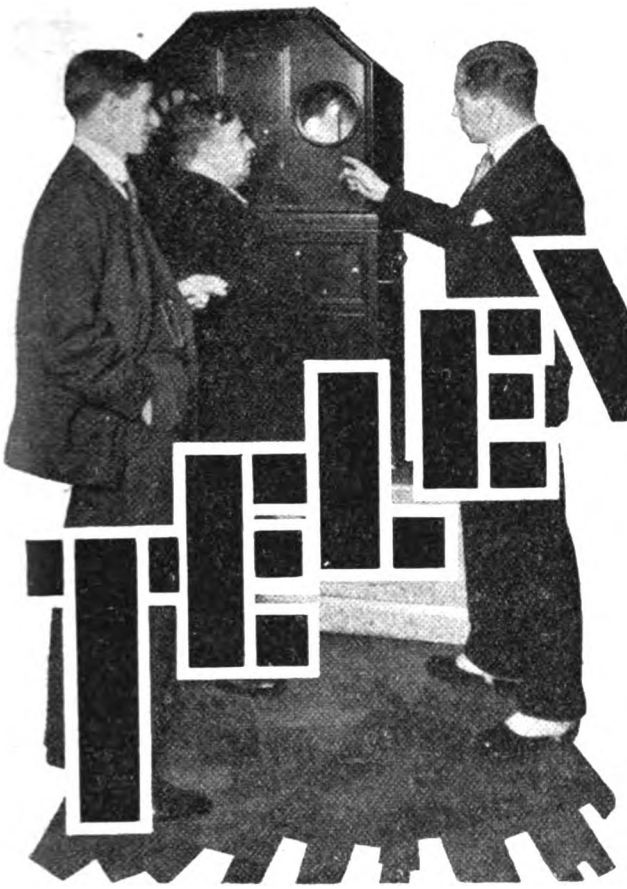

TELEVISION

THE OFFICIAL ORGAN OF THE TELEVISION SOCIETY

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VOL. II] DECEMBER 1929 [No. 22

EDITORIAL

OUR first duty this month is to thank the large number of our readers who answered the questionnaire card included in our last issue. The number and nature of the replies reveals that we have the interested and wholehearted support of our readers, who are as anxious as we are ourselves to make TELEVISION more extensive in scope and as perfect a magazine as possible.

The comments and suggestions made, although in some cases contradictory, were of great interest and value. With one or two isolated exceptions, our new "layout" is heartily appreciated. Some of our readers want us to publish nothing but technical articles. An equal number complain that we already have too many technical articles and wish us to include more matter of a lighter character. A limited number ask us to steer a middle course and make the magazine more general in its appeal. Well, it is impossible completely to please everybody, and a middle course appears to be the only possible compromise.

A number of readers suggest that it is time that we had a new cover, more up to date. With this sentiment we agree, and new cover designs are now being considered. It is hoped that we shall be able to introduce our new cover with our January, 1930, issue.

Almost all the replies express a desire for more constructional articles. There have been several reasons for our delay in publishing such articles. In the first place it was only recently that the Baird Company revealed certain essential facts concerning their apparatus, such as the number and diameter of the holes in the scanning disc, picture ratio, and, most important of all, the automatic synchronising gear. We had no desire to repeat the mistake made in America a year or so ago, when instructions were published, and kits of parts sold, which did not include any means for attaining synchronism other than manual adjustment of the speed of the receiving motor. The resulting disappointment produced, in America, nothing but disgust for television, and stultified at birth public interest in the new science.

After the Baird Company revealed the necessary information, and television broadcasting commenced, there was still, so far as we were able to gather, some doubt as to whether the scanning disc then in use would remain standard, or whether, in the light of broadcasting experience, and for other reasons, it might not be altered. We have now succeeded in obtaining some

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definite information from the Baird Company as to their plans, and this is contained in an announcement which will be found on page 492 of this issue.

One Remaining Problem

There is one remaining problem, however. Unlike wireless, television does not, at present, offer unlimited scope to the experimenter to try out all manner of combinations of parts, and, again unlike wireless, those parts cannot be made simply at home with the aid of a screwdriver and a pair of pliers.

The essential parts of a televisor are (1) motor, (2) scanning disc, (3) synchronising gear, and (4) neon tube. Few amateurs would care to make an electric motor, and fewer still are competent to make one which will run with sufficient accuracy for television purposes, and which will not cause interference to the adjacent wireless receiver and amplifier. In our next issue there will be a very interesting article on this latter problem.

Only those who have tried it know how extremely difficult it is to mark out and drill a scanning disc accurately with the tiny holes required. For perfect results this must be a precision engineering job. And even then, with expensive machinery to do the work, quite a number of discs have to be discarded as unfit.

The synchronising gear can be made by anyone who has a lathe, and is accustomed to working to a thousandth of an inch, but it is not everybody who has these facilities and qualifications. As for the neon lamp, it would surprise us if there is anyone in the country who could make up one in his own home.

These remarks may sound very discouraging, but they represent the facts which have to be faced. That they have not discouraged many of our readers we know from correspondence received, and that they will not discourage others is equally certain. Our statement of the case represents the position as it affects the man who wants the most perfect results possible. There are thousands more, as wireless has already proved, who welcome a difficult job for the sheer joy of overcoming the difficulties and, although aware that the results of the finished product are not perfect, glory in them nevertheless, because they have been obtained on apparatus which is the work of their own hands.

Motors and neon tubes can be bought. Scanning discs and synchronising arrangements can be and have been made by some of our readers, and they are getting results, according to reports which we have received. In this connection we shall be delighted to hear from any readers who have not yet written to us, and who are getting results from the present television broadcasts. We are out to make 1930 a television year, and we cordially invite your help and support to that end, and to the end that we may decide how best to help *you*. As a beginning, Mr. Waters' series of constructional articles enters, with this issue, upon an interesting phase, and we shall welcome in particular comments from those who act upon the instructions given.

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MSS. and other material for Editorial consideration should be accompanied by a stamped addressed envelope, and should be typewritten.

And now for some more replies to our questionnaire.

One reader suggests that, when apparatus becomes available on the market, we give, month by month, a review of this apparatus. That shall be done.

A New York correspondent expresses himself in the words: "Not so much Baird from cover to cover." There are several ways of answering this criticism. One is that in the early days of wireless one could write but little on the subject without mentioning the word Marconi. But we suspect that our American critic is somewhat annoyed because we do not refer to the efforts of the multitude of American television experimenters. If we did, we should only bore our readers with a repetition of technical details and principles with which they are already familiar. Baird led, and still leads, the world in television development, and in chronicling his progress we chronicle the work of successful television workers the world over. There are, of course, exceptions, and whenever anything of interest or importance occurs in any country, we publish details as soon as they become available. Finally, American journals take good care to boost American inventions. We support British inventions.

Sydney A. Moseley is unquestionably the most controversial of our contributors. It is not surprising, therefore, to find that some of our readers want his articles eliminated. But five times as many enjoy them and want them continued!

In conclusion, Christmas is almost with us again, and we allocate our last words to you on this page to wishing you all most heartily the compliments of the season.

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Educational Uses for Television

By *Sir Ambrose Fleming*, F.R.S.

NOW that television is an accomplished fact and the images of living and moving objects can be transmitted to, and seen at, distant places both by wireless and by wire transmission, an interesting question presents itself as to the nature of the objects the images of which can be so transmitted or televised.

We have to accept the fact that there is a very definite limitation at present to the size of the objects which can be televised or of the images which can be reproduced by the sizes available for the surface of the neon lamp, which up to the present has been the only available light source for reception. A further limitation (for broadcasting purposes) is imposed by the narrowness of the available wavebands.

Suitable Subjects

Such objects as the human face or the head of a large dog, or a cat, can be and have been successfully "televised." However, unless celebrated persons or those with very handsome countenances or singers or speakers can be induced to "sit" for such television, it seems probable there may be a limit to the public interest taken in it.

What is now required is a large range of objects suitable for television.

At the end of this article I have made suggestions for modifications of the transmitter which will enable objects in a horizontal position to be televised.

At present I confine myself to certain suggestions for the televising of astronomical objects. Of all these the full moon is our most attractive nocturnal object, and the question has been raised as to whether it would be possible to televise the full moon or even a lunar eclipse or a partial or total solar eclipse, so as to be seen simultaneously by many people at distant places.

The only practical method by which this could be done is by forming a good optical image of the celestial object by means of a large achromatic lens or concave mirror, and then treating this image as an object to be scanned by the revolving disk with its single turn of spiralized holes.

To fix our ideas, let us suppose a scanning disk made 12 inches in diameter. Let it have 30 holes in it, each about one-thirtieth of an inch in diameter, and let these holes be spaced 1 inch apart in a spiral of one turn with 1 inch pitch.

Suppose this disk geared to the shaft of a motor so as to be revolved at the rate of 1,000 turns per minute, which is quite feasible.

Let a sensitive photo-electric cell with a cathode surface of rather more than 1 inch in diameter each way be placed immediately behind this disk. Then form on the other side of the disk an image of the full moon, 1 inch in diameter. As the scanning disk revolves, the holes will pass across the fixed optical image in successive adjacent lines and "scan" it.

Before we go any further we must inquire into the "candle-power" of the moon. The intensity of a source of light is now measured or estimated in "International Candles," which may be taken roughly to be the intensity of a good paraffin, wax or stearine candle. If such a candle is held in a dark room 1 foot from the surface of a sheet of clean white paper, the illumination or brightness on that paper is called 1 *candle-foot*.

We find by trial that this illumination of 1 candle-foot is the least by which we can see to read comfortably an ordinary newspaper. Anything rather less than this illumination soon fatigues the eye, and for anything less than about ½ candle-foot ordinary book type cannot be read at all.

Illumination produced by Moon.

Experiment has shown that the illumination produced by full moonlight out of doors is not much more than one-fiftieth of a candle-foot. If any one tries the experiment in this country of reading a newspaper by full moonlight out of doors with no other artificial light near by, he will find out how very feeble the illumination produced by the full moon is in fact.

The question next arises, how can we form an image of the moon 1 inch in diameter, and what will be the brightness of this image? The moon in astronomical language has an apparent angular diameter of about half a degree.

Artists and others who represent the full moon in pictures often give it a very exaggerated apparent diameter. Most persons, if asked how large the moon looks, would say as large as a shilling, or some would even say as large as a dinner-plate. As a matter of fact the full moon is just covered by the width of an ordinary pencil held at arm's length, or say, 30 inches from the eye. It would be just covered by a halfpenny held 10 feet from the eye.

When an image of an object is formed by a convex lens or concave mirror, the apparent diameter of the image as seen from the centre of the lens or mirror is the same as the apparent diameter of the object as seen from the same place by means of the unaided eye. Hence it is clear that to form an image of the

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moon 1 inch in diameter we should require a lens of a focal length of 10 feet.

The amount of light collected in this image is the same as that which falls on the lens from the object. Accordingly, if a lens 7 or 8 inches in diameter and of 10 feet focal length is used to form a real image of the full moon, that image will be 1 inch in diameter and will have a brightness of about 1 candle-foot.

The light which passes through the holes in the scanning disk will then perhaps be enough to generate a useful current in the most sensitive form of photo-electric cell, but the brightness of the image can be increased by using a larger lens.

Now an achromatic lens of 7 or 8 inches in diameter would be a rather costly thing, but a silver-on-glass concave spherical mirror, as made by Sir Charles Parsons process, would be far less costly than a lens and would do just as well.

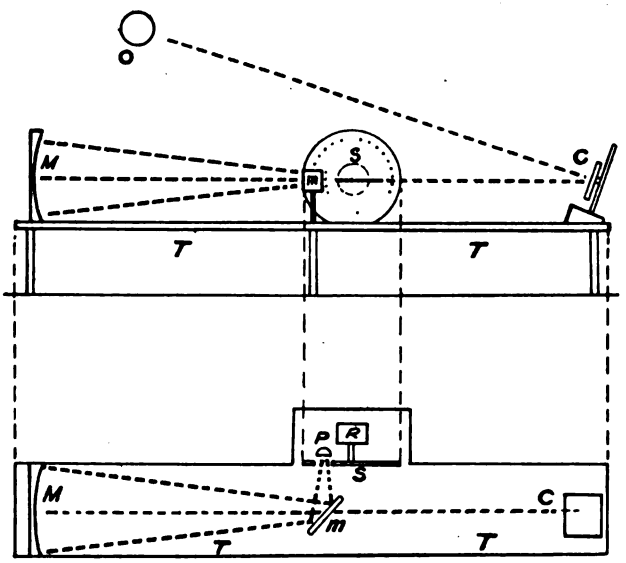

Fig. 1.—Elevation and plan views of a form of horizontal Newtonian telescope.

TT, *table*; M, *concave mirror*; m, *small plane mirror*; C, *cœlostat*; S, *scanning disk*; R, *driving motor*; P, *photo-electric cell*; O, *the moon or sun.*

Theory shows that for such a spherical mirror the radius of curvature is double the focal length, and also that for an object so far off as the moon the image would be formed at the principal focus, or half-way between the centre of curvature and the mirror surface. Hence we should require a concave mirror of 20 feet radius of curvature.

If such a mirror could be made by the silver-on-glass process of about 1 foot or more diameter, we should obtain by it an image of the moon having a diameter of 1 inch and a brightness of nearly 2 candle-feet, which would be sufficiently bright to produce an adequate response from a photo-electric cell.

For convenience of operating it might be necessary to employ a plane mirror called a cœlostat to reflect the rays from the moon constantly in one direction, and then to allow these rays to fall on the concave mirror and form a real image on the scanning disk surface.

If this could be "televised" we might exhibit not only a full moon but a half-moon, and also perhaps a lunar eclipse in its preliminary stages.

The same optical arrangements would give an image of the sun similar in size to that of the moon, since the apparent diameter of the sun is also about half a degree.

The clear sun, however, gives us nearly 400,000 times the light of the full moon. Full sunlight therefore produces on white paper exposed normally to the rays an illumination of about 7,000 to 10,000 candle-feet.

It is, however, easy to weaken the intensity of the light by dark glasses as is done in a sextant. It might, therefore, be an easier matter to "televise" the sum than the moon, and in this case a much smaller achromatic lens of 10 feet focal length would give the image required.

In order to carry out the above suggestions, possibly the most suitable method would be to construct a sort of horizontal Newtonian telescope on the lines shown in Fig. 1.

A long horizontal table must be provided, about 15 feet in length. At one end of this table must be placed the cœlostat, which is a plane mirror attached to an axis which is parallel to that of the earth. If this mirror is fixed in a proper position it will reflect the light of the sun or moon along the table. At the other end of the table must be placed a Parsons silver-on-glass concave mirror of 20 feet radius of curvature and 10 feet focal length. The diameter of this mirror might be 24 inches. This will form an image 1 inch in diameter at the principal focus. Then a small plane mirror or totally reflecting prism must be placed about 6 inches or a foot from the principal focus nearer to the mirror, so as to turn the rays out at right angles and enable the image to be thrown on to a scanning disk, the plane of which is parallel to the length of the table. Behind this scanning disk is placed the sensitive photo-electric cell of such construction that the cathode surface is not quite covered by the optical image.

Then there must be the usual arrangements for amplifying the photo-electric current and transmitting it to the distant receivers.

To secure good results the cœlostat would have to be slowly rotated by an astronomical clock so as to keep the image perfectly steady in one place on the scanning disk, in spite of the diurnal motion of the earth and moon, as is done in eclipse photography. I am pretty confident, however, that with these arrangements it would be quite possible to televise the moon.

Moreover, I am inclined to think that the same kind of apparatus could be used to televise full length images of human beings doing certain things, such as playing the violin, fencing, boxing, or dancing. It would, however, require a shorter focus mirror and some modification of the optical arrangements.

As regard the planets, it is out of the question to televise them. Even the brightest of them, viz., Venus at her best, has an apparent diameter of only 67 seconds, which is less than one twenty-fifth of the apparent diameter of the sun or moon. We cannot

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therefore hope to produce an image even of Venus of the required size and brightness.

The following table gives at a glance information as to the apparent diameter of the sun, moon, and planets, and of the images of them formed by a lens of 10 feet focal length. Suppose we place a half-

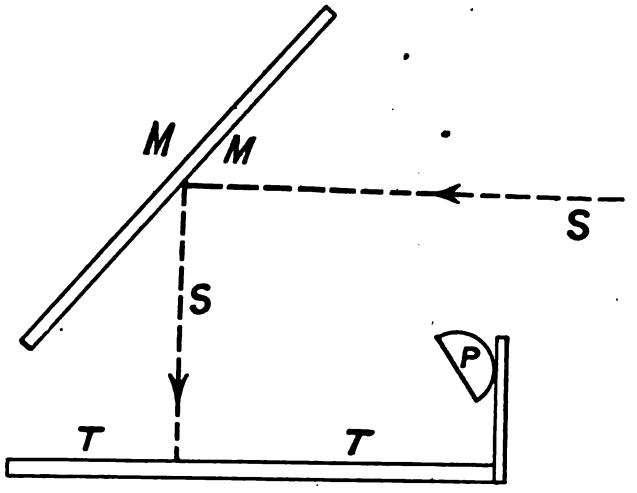

Fig. 2.—Arrangements for scanning objects on a horizontal Table, TT.

M, large plane mirror inclined at 45°; SS scanning ray of light; P, photo-electric cells.

penny at such distances as to appear as large as these celestial objects, then these distances must be—

Sun	..	10 feet
Moon	..	10 ,,
Venus	..	268 ,,
Jupiter	..	360 ,,
Mars	..	720 ,,
Saturn	..	900 ,,
Mercury	..	1,385 ,,

All taken to agree with the apparent diameter of the object when at its position of maximum apparent size.

Then the diameters of the optical images formed with the above-named lens would be—

Sun	..	1 inch	Mars	..	$\frac{1}{72}$ inch
Moon	..	1 ,,	Saturn	..	$\frac{1}{90}$,,
Venus	..	$\frac{1}{27}$,,	Mercury	..	$\frac{1}{140}$,,
Jupiter	..	$\frac{1}{36}$,,			

From these figures it will be seen that there is no possibility with any easily contrived means of making a planetary image large enough and bright enough for scanning.

Another suggestion I wish to make relates to the televising of things which can only be placed in a horizontal position.

At present the " subject " being televised sits up in front of the scanning disc and lantern. The scanning ray of light is horizontal in direction and moves across the face vertically or horizontally. However, there are many things which cannot be placed in such a position, but must be horizontal.

Suppose, for instance, we wish to televise the lines of force round a magnet made visible by means of iron filings sprinkled on a sheet of paper laid over the magnet. This last must then be placed in a horizontal position.

To televise this object I suggest the following arrangement. Let a large plane mirror be placed at an angle of 45° and so held as to deflect the scanning ray from the horizontal position vertically downwards (see Fig. 2). The photo-electric cells would then have to be placed so as to receive only the irregularly reflected light scattered from the paper, but all other arrangements would remain the same. With this reflecting mirror we could televise the ripples formed on mercury or water contained in a flat shallow saucer or plate. Also experiments on surface tension could be shown, such as camphor fragments running about on water.

There is, in short, no end to the scientific experiments which could thus be televised in a horizontal position.

One more suggestion I have to make with regard to viewing these images.

With the present Baird receiver it is difficult for more than two or three persons to see the image continuously without getting in each other's way, and people therefore have to take turns in seeing it if a number are present. The projection of the image on to a screen so as to enable a large number of persons to see it requires some elaborate appliances at present. The following plan will, if I am not mistaken, enable half a dozen, or even a dozen, persons to see the image simultaneously.

Over the large lens or viewing aperture of the Baird receiver must be placed a large looking-glass like an overmantel, about 3 feet long and 2 feet

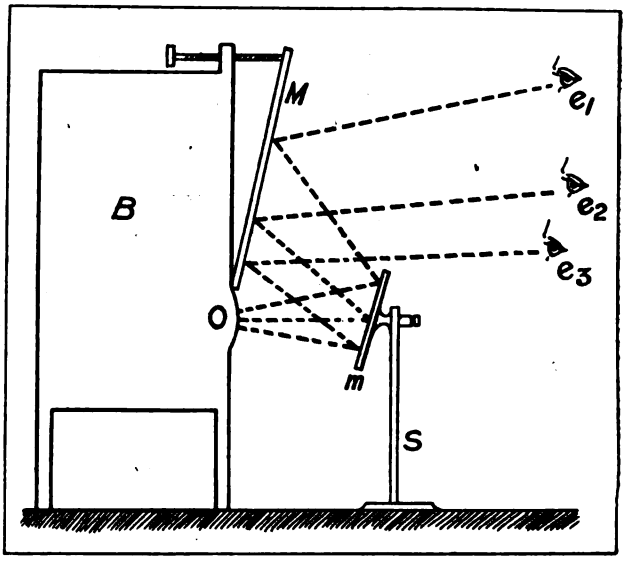

Fig. 3.—Arrangements to enable a number of persons to " look-in " simultaneously with a Baird Television Receiver.

B, Baird Television Receiver, side view; O, lens; m, small plane mirror; M, large inclined mirror; S, adjustable stand; e_1, e_2, e_3, eyes of observers.

wide. This must be capable of being tilted by a screw so as to incline it slightly at the top forwards. Then a smaller plane mirror, about 8 or 9 inches wide and 24 to 30 inches long, must be fixed to a stand like a tall retort stand, and this also must be capable of

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being tilted by a screw. Looking at the arrangement from the side, as in Fig 3, it will be seen that the rays of light coming out from the aperture of the television receiver fall on the small mirror and are reflected upwards on to the large mirror. Persons standing behind the small mirror and looking into the larger one will see the television image after two reflections. I am inclined to think, after a rough trial with two mirrors, that even a dozen persons may in this way see the television image comfortably.

This is important, because if we wish to give by television a science lecture to a class of boys, each boy must be able to see the image all the time quite independently of other boys. The verbal instruction would be given simultaneously by the loud-speaker embodied in the television receiver.

I look forward to the possibility, when the mental vision of the B.B.C. has been enlarged by the pressure of facts, to the broadcasting of educational lectures or talks which will appeal to the eye as well as to the ear, and it will be possible then to " look-in " as well as " listen-in " to public teaching.

Educational Aspects of Television

THE educational factors inherent in television are of obvious importance. The psychological effect of instantaneous observation of phenomena as they occur is of very great value. The attention and interest of students and the public is greatly enhanced by the ability to see and hear simultaneously. The personality and features of the speaker, singer or performer are faithfully transmitted with photographic accuracy. A lecturer can illustrate his subject by showing the objects he is discussing and make the information clear by supplementary sketches and diagrams.

To indicate the essentially practical character of this new technical facility a few examples will be of interest. By means of a blackboard and chalk, or, obversely, a white board and charcoal, text, numerals and illustrative sketches may be instantly televised. A lecturer on geometry can show diagrams and models of cubes, cylinders, prisms, conic sections or other solid figures. A demonstrator of chemistry, by the use of flasks, beakers, test tubes and accompanying apparatus and materials can show practical experiments. The results of electrical and magnetic tests can be indicated on instruments of precision such as galvanometers, ammeters, etc., and lines of force illustrated by magnets and filings. The technology of industry may be definitely illustrated by moving models of mechanical and physical apparatus of many kinds, for example, the internal and external movements of a section of an internal combustion engine. Geography, astronomy, microscopy and other sciences may be made intensely live subjects by the use of maps, orreries, magnified micro-objects, etc. The natural history student can be shown living or inanimate objects with perfect clarity, and such varied sciences as botany, biology, anatomy and anthropology become of singular interest when the images of objects are transmitted by means of television. History can be illustrated by pictures of events and personages of all periods.

Both the fine and applied arts will receive a stimulus when television is universally available. Fine pictures, sculptures and artistically designed objects of various character will form a very important item in television broadcasts. Photographs are transmitted with an astonishing wealth of detail. While drama cannot yet be shown on the large scale of the theatre or cinema, dialogues, debates and small scale plays comprising three or four characters can easily be transmitted. Music score may be shown by the standard and other notations. Of unequalled importance is the instantaneous transmission of news and captions in the caligraphy and printed characters of any of the races of the world, thus making television a world-wide means of educating all peoples of whatever racial origin or degree of educational progress.

A further development is the immediate practicability of the instantaneous broadcasting of talking films, which may be devised for greatly differentiated educational purposes. In the near future also there will emerge from the research stage the projection of the televised images upon a screen, as in the cinema, so that, in addition to home reception, large classes of students and members of the public may see the transmissions simultaneously.

It will be realised from the foregoing brief statement that the present potential educational position, apart from future possibilities of television, is already of enormous value. The universal application of this means of visual communication as an aid to education, both elementary and adult, will result in a new conception of both national and international contacts, on a plane hitherto considered to be a dream of the imagination.

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Mains Brevities

PART II

By *William J. Richardson*

(Continued from our August issue)

IN the August issue of TELEVISION I dealt with many important points arising out of the use of D.C. mains, including their employment as an aerial, smoothing devices, feeding filaments in series and individual control, and we left off by querying the possibility of using the voltage normally wasted in running the filaments to supply the H.T. Before considering this, however, attention must be paid to a detail arising out of this filament and H.T. series working. Some may be inclined to dismiss the point about to be discussed as trivial, but imperfect set working frequently can be attributed to this cause.

A Series Filament Detail.

We know that a current of electricity is a flow or drift of negative electrons from the negative to the positive potential, that is, in the opposite direction to the conventional way of illustrating current flow. With a valve in operation, however, the current flow is not confined to the filament boundary but takes place in the plate circuit as well, due to an evaporation of electrons at the filament surface and their subsequent attraction to the plate when a positive potential is applied to that electrode.

Assuming H.T.—and L.T.—are common, Fig. 1 will explain what is meant if we take 5 milliamperes as being the total plate current and 100 milliamperes as the filament current. In the negative filament lead we shall have the full current flowing, but in the positive lead only 95 milliamperes return, and this difference can be registered if suitable meters are included in each lead. With parallel valve filament working, such as we normally get in battery-fed receivers, the effect is localised in each valve and does not generally produce any untoward effect, but what will happen with series filament working?

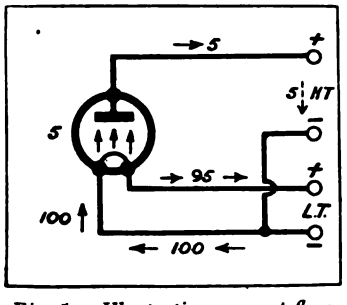

Fig. 1.—Illustrating current flow in a simple valve.

When we desire to reduce current consumption by working the filaments in series and having the resistance which normally cuts down the voltage as a source of H.T., then Fig. 2 will represent the situation for, say, a three-valve set with valves all of the 100 milliampere class. If the first valve is running normally, then the other two valves are being underrun and distortion is likely to result, especially in the last valve. If we arrange for the last valve to be correctly adjusted, then the first two valves will be overrun and this will shorten their useful life. Furthermore, it will be necessary to bear in mind that, owing to the varying currents flowing in the resistance, the H.T. voltages will not be directly proportional to the actual resistance tapped off, which would be the case if the same current flowed throughout the resistance.

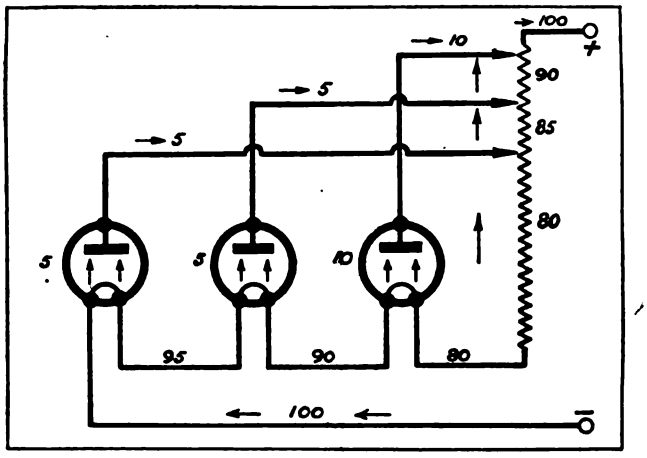

Fig. 2.—Series filament working showing current distribution.

The Complete Arrangement.

The situation, as far as the filaments are concerned, can be adjusted quite easily if we are using a power valve in the last stage, since this invariably demands a higher current than prior valves, and it will be necessary to add parallel resistances across these preceding valve filaments to by-pass excess current as shown in the previous article, and this will rectify matters. A reference to Fig. 3 will show exactly what is meant, the figures referring to currents in milliamperes, and in a case such as that illustrated no adverse effects will occur as a result of our more economical filament working. The actual value of the resistance for the H.T. tappings will, of course, depend upon the maximum filament current and the mains voltage, and is found by dividing the voltage by the amperage. Allowance must be made for any intermediary resistances, choke resistances, etc. The

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smoothing arrangements will now be somewhat modified, the inductance values of the low-frequency chokes depending upon the "roughness" of the mains, but 30 henries is generally the *barest* minimum.

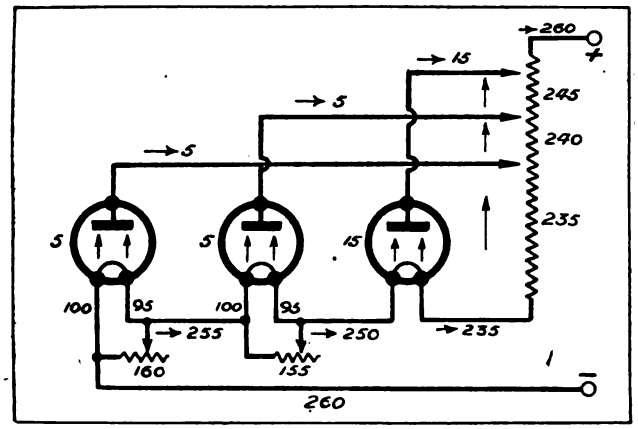

Fig. 3.—Balancing up the "current lost" by parallel resistances.

To adequately smooth D.C. mains is always a fairly difficult problem and, apart from the usual method of using chokes and condensers of appropriate size, many ingenious schemes have been propounded. One which I have used with marked success on a number of occasions makes use of a two-electrode valve (or a three-electrode valve with grid and plate joined together) in quite a novel manner. Choosing a valve which has a definite "saturation current" and will work in this condition for long periods, the characteristic curve will be as indicated in Fig. 4A, the horizontal curve *AB* representing saturation conditions.

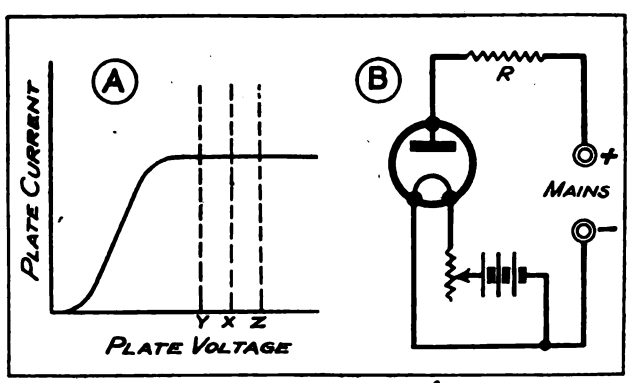

Fig. 4.—A novel smoothing scheme.

Now suppose the plate voltage is adjusted to the point *X*, then any increase or decrease of plate voltage within the limits *YZ* will not cause any current change. That being the case, arrange the valve in circuit as Fig. 4B, a resistance *R* being connected between the positive main and the valve plate, and adjust this resistance so that the actual plate voltage is about 20 volts in excess of saturation voltage. Thus, with 240-volt mains and a valve with a saturation current of 10 milliamps. at 100 volts, the plate voltage of 120 volts would be given by

$$\frac{240-120}{\cdot 01}=12{,}000 \text{ ohms.}$$

Consequently we have available across our resistance *R* a steady D.C. voltage of 120 volts, for with a mains rise or fall of 5 or even 10 volts the saturation current remains the same and hence the voltage drop across *R*. The valve can be looked upon as absorbing the fluctuating voltage. While any reduction of *R* will not cause a current decrease, the useful voltage available will be decreased, but if we increase *R* above the limiting value set by the valve saturation voltage then the scheme will not function. A milliammeter is therefore advisable in the valve plate circuit.

It is possible to run the absorbing valve filament from the mains providing it is a thick one, that is, one of the heavier filament current type. Under these circumstances the variation of voltage applied to the filament as a result of line fluctuations will be followed very slowly by temperature changes in the filament, a time lag effect making its appearance. The small change in filament temperature brings about a small change in saturation current and this will be passed on to the voltage across *R*. The effects are small, however, in comparison to the original mains fluctuation and can be minimised still further by shunting *R* with, say, a 5 mfd. fixed condenser.

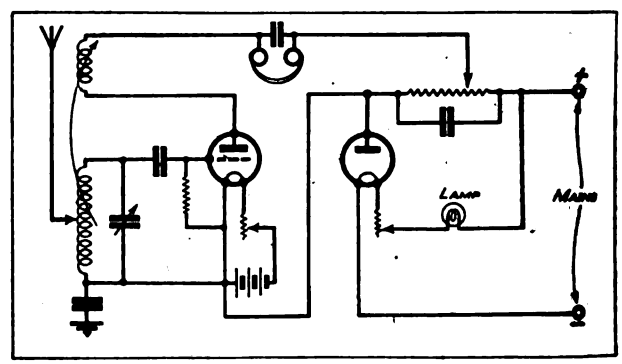

Fig. 5.—A simple single valve set complete with H.T. smoother.

Fig. 5 gives a simple single valve circuit used in conjunction with this valve smoother, and the scheme is capable of further development in so far as the feeding of both H.T. and L.T. are concerned. The difficulty here is to find a smoothing valve (or two valves in parallel) whose saturation plate current is just in excess of the normal filament current of the receiver. Valves of the L.S. 5 or D.U. 10 class are suitable, but the arrangement is not recommended for multivalve receivers. Sufficient has been said, however, to prove that really excellent results can be secured from D.C. mains receivers, the secret of success being based primarily on a knowledge of local conditions as far as the raw mains supply is concerned.

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America *and* Television Progress

By *J. M. Verralls*, A.M.I.R.E.,
Fellow of the Television Society

IT was with interest that I recently read Mr. Shaw Desmond's article, "Selling America to the World," in the October issue of TELEVISION, and I would like here to support Mr. Shaw Desmond's contention that America intends to use television as her weapon for gaining supremacy in the entertainment field of the world.

The Jenkins Receiver

At the recent Radio World's Fair at Madison Square Garden, New York City, television was the most popular attraction. The Jenkins televisor, which is the best known in America, has made vast strides towards simplicity of operation, consistent with good reception results. As many stations are already transmitting television signals it is expected that this receiver will be in greater demand within a short period, because, I understand, several other television stations are under construction at this present time, and are shortly expected to be "on the air." The latest reports of the United States Radio Commission show that many applications have been made for the transmission of television signals during the coming year.

I was recently advised by the Jenkins Television Corporation that they expected an output of about 5,000 units during 1929, and that production is being expanded. Affiliation with the DeForest Radio Company assures distribution through approximately 5,000 dealers. I also understand that this corporation has other mergers in view, especially in connection with the transmission of moving pictures, which will be an everyday occurrence in the near future. It is estimated that the number of radio listeners in the United States of America has increased from 60,000 in 1920 to more than 50,000,000 at the present time. With such popularity in a vast industry like radio in America, surely it is time Great Britain made efforts to hold supremacy in the newest method of communication—television.

Since the passing of the White Act in 1927 (which, in plain words, forbids any purchase of radio by cables or *vice versa* in the United States), television is undoubtedly the weapon that will be used to gain leadership in the entertainment of the world. Using the expression "entertainment of the world" no doubt sounds somewhat ridiculous to many people, but I venture to say that such a term is not exaggerated, for only as recently as October 21st I was listening to Professor Albert Einstein's speech from Berlin being broadcast to practically every country in the world, through the medium of long and short wave stations in the United States, which experiment proved quite a success. Before long, no doubt, such world-wide broadcasts will be a regular occurrence.

The number of persons employed in the radio industry in America has risen to a figure estimated at 320,000 a few months ago. Now that television has aroused public interest this number has already greatly increased. Television is likely to make swifter strides towards perfection in America owing to the fact that the restrictions by the Government are not so rigid as those enforced by the British Government. The United States Government has given every encouragement to television and, furthermore, has helped in many ways to assist the inventors of the various systems now patented in America.

Radio—Cinema—Television Mergers

In the *Saturday Evening Post*, one of America's most popular magazines, there appeared an article written by General G. Harbord, President of the Radio Corporation of America, with the intention no doubt of impressing upon the American public the need for the reorganisation of American communications, since the recent merger of British communications had captured world leadership. Mr. Shaw Desmond states in his article that "television is to be the weapon which America will use to gain leadership in world-wide entertainment." Having just spent some 18 months in New York I am fully able to confirm this statement, as I have watched the steady growth of television, and the more recent plans under consideration with respect to the merging of motion-picture companies with radio and television companies.

If Great Britain holds the leadership of the communications of the world, as is admitted by America, is she going to let the newest system of communication (which was born in Great Britain) pass out to America, and thus let the American dollar establish a monopoly of television throughout the world? I hope not.

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Television *and* What Shall

PEOPLE *will* talk, and the prolonged absence of television in purchasable form has provided an excellent subject for conversation. There are those who say that the Baird principle has such serious limitations that it will be short-lived. The contention is fundamental and must not go unchallenged. Indeed, the fact that such a view is being advanced by men of academic distinction makes an examination of the facts imperative.

At the outset it should be made clear that failure to grasp the immediate value of Baird's invention is attributable mainly to ignorance. There is a disquieting scepticism abroad which is affecting even the most credulous. As time goes on, however, it becomes clear that the cause is mental rather than mechanical—psychological rather than economic.

The Inventor's Advantage

It is a curious fact that the inventor can afford to be more sure of establishing a fundamental advance in applied science than can the pure scientist in abstract theory. The scientist has frequently to abandon his theories as new factors press for consideration. Not so the inventor. His steam-engine may have a thousand modifications and adaptations, but the invention preserves its identity. It is significant that the greatest inventions have sprung from co-ordination and rightful use of existing principles—each individually proved and evaluated by the inventor—rather than by the creation of something wholly original.

Baird is an inventor. His work has evidenced that practical thoroughness which we should expect. Never has he claimed that the achievement of television was due to his unaided endeavour.

Our contention that his method of achieving television is unlikely widely to be departed from is not difficult to uphold. There has been an extraordinary sequence of contributory inventions which have come to the aid of Baird as he has proceeded with his task. The Nipkow disc, the neon tube, the photo-electric cell—each in turn has contributed vitally to the ultimate achievement. But we may rest assured that Baird has not concentrated on one line of development to the exclusion of others. Long years have been spent by him in exploring every possible avenue of approach to the desired end. We must not forget that it was not enough simply to accomplish television in the laboratory. Baird had to face the fact that no system of television could be commercialised which did not conform to the existing conditions of wave-band allocation.

Criticism has been directed at his scanning method. Probably the criticism has its origin in a growing hope in lay circles that some form or combination of photo-electric cells will be developed which will be sufficiently sensitive to pick up the detailed image of a normally lighted room and transmit it unscanned. Whether this ideal will be achieved or not it is impossible to say, but it is important to notice that other experimenters have failed to outrun Baird by recourse to any method widely divergent from his, and that from 1925 onwards he himself has continued to follow the same general principle. People who sneer at the scanning-disc in television may be likened to those who ridiculed the use of the propeller in the beginnings of aviation. How indispensable it has become!

But there is another reason for our contention that the Baird principle will persist. The method employed by him is commonly supposed to be extremely complicated, whereas, in reality, the principle now standardised in mechanical form is as simple and straightforward as any could well be. For this reason,

After all the pushing and struggling, how much did you see of His Majesty? Television can bring into your own home a better view than you will get in this crowd.

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the Public We See?

By *Leslie Trenton*

if for no other, it is most likely to survive. It will be developed ; it will be adapted ; but the principle will persist. Its simplicity is of the order commonly associated with the greatest achievements of science. There is yet another reason. In

Germany the subject of television has for some time been receiving the closest attention. Her greatest minds have been called to bear upon the problem. But it is of overwhelming significance that whilst important work is still being carried out by German experimenters, it is the *Baird* system which, by virtue of its *immediate* practicability and value, has been adopted and launched as a commercial proposition by a combine of three well-known German companies.

Impeding Factors

In Britain the task of commercialising television has been retarded by the spreading of fantastic stories—stories which, strangely enough, have found credence in otherwise well-informed circles. Even now many people visualise television as being comparable with a large-scale cinematograph. Those who have had the opportunity of seeing television for themselves, however, have at once realised the magnitude and significance of the accomplishment at its present stage of development and the practical use to which it can immediately be put.

In the broadcast of public functions lies, perhaps, one of television's most obvious applications. It will make news *live* as it brings familiar personalities into the home. Think, for instance, of the interest it will arouse as it shows us the Prince talking in Africa or the Premier speaking at Westminster.

The King's return to London, the home-coming of Ramsay MacDonald and a host of similar events suggest material peculiarly suited to broadcast by television. Ask the average spectator of such an event what he went to see. Obviously he did not go to see the crowd. He did not go because he enjoyed being jostled and trodden upon. He will tell you that

Did you go to see this crowd, or the personality within the circle Television can show you this NOW —— in comfort.

what he *did* go to see was the *individual* occasioning the demonstration, and, most probably, that he had but a fleeting glimpse.

If we will consider the circumstances of any of these events we shall realise that there is always some *central personality* commanding and riveting the attention. Look at the accompanying photographs. What more convincing testimony could there be ? Remove the central figure and the point of attraction and interest disappears with it. The same applies to the cinematograph. Because the personalities are of primary importance, they are repeatedly presented to us in the form of " close-ups." Similarly, in everyday experience, it is the facial expression which, when accompanied by the human voice, enables us to appreciate the personalities of our friends.

The Blindfold Listener

Now think of the frequent attempts that are made to broadcast by visionless radio public functions of any kind. How miserable is the failure to convey the personality and therefore the spirit of the event to the blindfold listener !

As 1929 draws to a close there are welcome evidences that the barriers of conservatism and misapprehension that have hindered the issue for so long are rapidly being broken down and that the commercialisation of television in this country is imminent. If by co-operation the task is handled in the right way, there need be no misgivings as to the response of the public or the benefits that will accrue.

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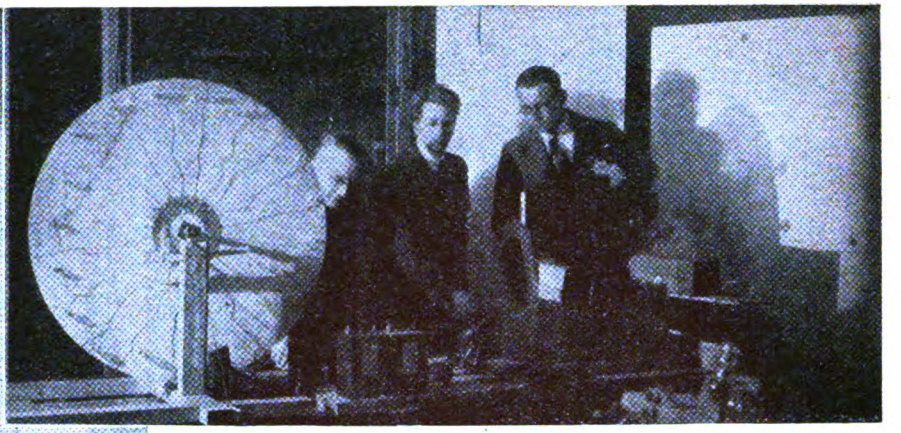
HASTINGS MAKES HISTORY.

Councillor A. D. Thorpe, J.P., Mayor of Hastings, and Mr. Baird, photographed under the plaque after the unveiling ceremony.



The late William Le Queux (left) examining Baird's early apparatus at Hastings.

(Below) The Mayor of Hastings unveiling the plaque. See article on opposite page.

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Hastings Honours Baird

Details of a Simple Ceremony

TO Hastings belongs the unique distinction of having honoured an inventor and recognised his work during his lifetime. On November 7th the Mayor of Hastings, Councillor A. D. Thorpe, J.P., unveiled a bronze plaque attached to the partition wall of one of the shops in the Queen's Arcade, Hastings. The plaque bore the inscription: "Television. First demonstrated by Mr. J. L. Baird, from experiments started in 1924."

Although Queen's Arcade is quite close of the Hastings Town Hall, it is quite an unpretentious passageway. The shops which line it are mainly of the small lock-up variety, and deal with the usual sort of fancy goods and novelties that one expects to find on sale at a popular seaside resort. Each of them has a single storey over it, and it was in one of these rooms that Mr. Baird started his work. In 1924 the shop beneath him dealt in artificial flowers; this shop has since changed hands, and the goods on sale now consist of gramophones, wireless apparatus and snapshots of visitors taken in the streets. The building is not the sort of place one would expect as the habitation of an inventor, but then inventors are invariably folk who are not influenced by surroundings.

Unconventional Apparatus

Up aloft in this laboratory in 1924 Baird was as unconventional in the apparatus he used as any other discoverer. Strictly limited as to financial resources, he was unlimited in ingenuity. At that time, as most amateur wireless enthusiasts are well aware, there was a vast amount of cheap but very good ex-Government wireless apparatus to be picked up. Some of this formed part of his equipment. Accumulators supplied his filament current, but when it came to high tension voltages (and in his very early experiments he found it necessary to have very high voltages indeed) he did as every wireless amateur at some time or other has done—made up his high tension battery from numbers of ordinary pocket flash-lamp batteries linked together.

The most intriguing part of his apparatus, however, was the actual mechanism of the television transmitter and receiver. In these a truly wonderful collection of odd bits were put together and made to work. Scanning discs were made of cardboard; mountings for them were contrived out of the crudest and roughest types of timber; motors which should have gone to the scrap-heap, after an honoured service, were renovated and made to do duty in positions for which they were entirely unsuited; while, for the optical part of the apparatus, lenses from bicycle lamps (easily procurable at fourpence a time) were employed. Over, around and underneath the whole ran a jumble of wires of every conceivable colour and type, beside which the wiring of the most complicated telephone exchange looked simple.

With this thoroughly unpromising-looking collection, Baird not only succeeded in getting results—uncertain at times, but, when they did condescend to come through, definite enough—he also conceived, constructed in the same rough way and tested out most methods of television as at present being employed in America, Germany and elsewhere. The batteries, as can very well be understood, were his chief trouble. The current which gave satisfactory results one day had disappeared by the next, and many an anxious hour was spent chasing the elusive fault. Where other workers would have given up in despair, Baird went on, bought some more pocket flash-lamp batteries, and ran his faults to earth.

The very fact that he got results with such a nightmareish collection of impossible apparatus was a better proof than anything else that he was on the right lines to achieve television. This has been amply demonstrated by subsequent events.

At the unveiling ceremony on November 7th, which was exceedingly simple, Mr. John L. Baird, Dr. Clarence Tierney (Chairman of the Television Society), Mr. J. Denton (Honorary Secretary of the Society), Mr. W. C. Keay (Honorary Treasurer, Television Society), and a number of the Members of the Hastings Town Council, together with Mr. G. M. Norman (Headmaster of the Hastings School of Science), Captain P. S. Barlow (Headmaster of the Hastings Grammar School), Mr. E. H. Hole (Senior Science Master of the Hastings Grammar School), the Honorary Secretary of the Hastings Radio Society, and many others were present.

Sir Ambrose Fleming's Message

No speeches were made at the unveiling, but those present went across to the Council Chamber, where the Mayor announced that he had received a letter of regret for his absence from Sir Ambrose Fleming, which read:

> "I regret very much that another important engagement at the Institution of Electrical Engineers to-night prevents me from accepting the kind invitation of the Mayor of Hastings to be present at the

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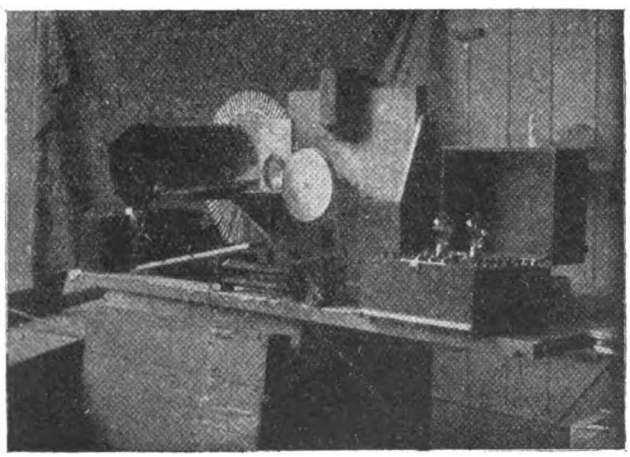
interesting ceremony of the unveiling of a plaque commemorating the historic and epoch-making work of Mr. Baird. This plaque will be a perpetual reminder that Mr. Baird was the first to effect practical television and to inaugurate a new departure in electric technics which will have immense developments in present and future years."

"We are very proud in Hastings," said the Mayor, "to be associated with the great name of Baird. Hastings has many distinctions, but perhaps this one in the years to come will be one of its most famous, and we are sure Mr. Baird is proud to be associated with Hastings. He will never forget his scientific achievements here, and the place where he worked." Mr. Baird, the Mayor continued, like many famous Scotsmen, was a son of the manse, and he thought he was probably correct in saying that, when he came down to Hastings, he was a struggling but intelligent young Scotsman. Mr. Baird represented for them a man who had conquered many difficulties. He had struggled for years, worked hard, and had had to negotiate many fences in his efforts to develop television. To-day he felt sure that although it was still not much more than a novelty, in a few years' time it would be a very important and practically universal feature of life. Just as Mr. Baird was the first to demonstrate true television, so, early in 1928, he was the first to send television across the Atlantic, to demonstrate television in colour and daylight television. "Mr. Baird is only 40 years of age," added the Mayor, "and we are looking forward to seeing him spared in health and strength to carry on his invention to very great lengths indeed and to be one of the most famous men in England."

Mr. Baird, replying, thanked the Mayor and the people of Hastings for the honour and pleasure they had given him. "When I arrived in Hastings in 1923," he said, "I came in search of health after a serious illness and thought I should never be fit and well again; the doctor who sent me also thought the same, but in a very short time the exhilarating atmosphere of Hastings made me a changed man. While down here doing nothing I took up the study of television again. I had been interested in it since my youth, and when I took it up here, with the aid of some apparatus I managed to get together and the cordial assistance of a number of the Hastings residents, some of whom are present now, I soon began to get shadowy images to appear on the television screen. In talking about this phase of my work I should like to mention the late Mr. William Le Queux, who was present at a number of my experiments and wrote of what he saw in the *Radio Times* and other journals.



Another view of the apparatus used by Baird at Hastings.

"In a little back room"

"In a little back room above what used to be an artificial flower shop in the Queen's Arcade, these first experiments were carried out, and although nothing very much was seen through these early machines it was sufficient to show that the right path was being followed. It is interesting, too, to note that the machines now used are, in principle, almost identical with that early apparatus. I need not go into technical details, but there are the same neon tubes, the same disc with its holes, and the same type of motor to drive the disc.

"The progress after the foundations had been laid at Hastings was very rapid. A demonstration in London was followed by a demonstration to Members of the Royal Institution in 1926, and it was the first time that television had been demonstrated. At that demonstration we showed living human faces transmitted by television, and proved that the science of television had arrived. These demonstrations were followed by others, the necessary capital for development was secured, and television began to go ahead."

Mr. Baird again thanked the Mayor and people of Hastings for honouring him in the way they had.

Mr. W. G. Nye, Honorary Secretary of the Hastings Radio Society, said he wished to thank Mr. Baird, on behalf of all the local radio enthusiasts and all those interested in radio, for the future to which they could look forward, namely, seeing as well as hearing what was happening by means of wireless and television. They hoped to form a local Group Centre of the Television Society in Hastings. The objects of the Society were to further the science of television in all its forms. In Hastings they were anxious to get their Centre going as soon as possible, as, if they did not, their rivals at Eastbourne might precede them, and then Hastings would have to form part of the Eastbourne Group Centre rather than be a Group Centre on its own. Such a state of affairs was unthinkable, when Hastings was the birthplace of television. It was up to all those interested in wireless and television to see that Hastings was one of the first Group Centres of the Television Society to be formed.

Dr. Tierney, who also spoke, said it is surprising how few people can read history in the making. They should feel privileged at having been allowed to take part in the writing of a page of it that afternoon, for undoubtedly that event, simple as it might appear, was a page in history that, as the years went on, might become a very important one.

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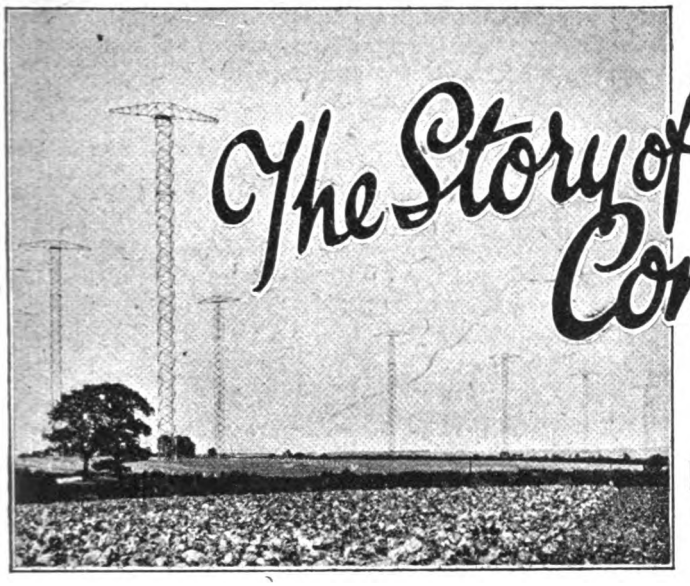

The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

PART XII.

WIRELESS AS AN AID TO NAVIGATION

WE have seen how Marconi in his earliest experiments made use of reflectors, with the object of increasing range, by emitting the wireless waves in a concentrated beam like a searchlight in the direction required, instead of allowing them to disperse in all directions. This arrangement, however, was only possible with very short waves, and as with the knowledge then available such waves were quite unsuitable for communication over long distances, Marconi soon discarded his reflectors and turned his attention to long waves with all-round transmission. But he never lost sight of his short-wave beams, and when, twenty-five years later, altered conditions allowed of the use of short waves for great distances, he started the experiments with his beam system which has revolutionised the whole outlook of wireless signalling—but that is another story.

It was clear from the first that a beam of waves would open up the way to navigation by wireless, as a shore station transmitting a beam in a known direction would allow a ship to obtain its bearings from the station when it came within the beam, that is, when it received the signals from the station. Obviously, however. for this purpose the beam must be very concentrated, which it has only been found possible to arrange for by making use of extremely short waves, far shorter than those used by Marconi in his long range beam system of communication.

Rotating Beacons

These very short-wave beams have not yet been adapted to navigational purposes commercially, though the Marconi Company has erected two experimental stations in this country, one in the Firth of Forth, and the other at the South Foreland in Kent. The transmitting aerial at these stations is mounted on a revolving carriage fitted with wire reflectors, which allows of the transmission of a rotating beam of waves. Distinctive signals are sent out as the beam passes through the different points of the compass. The ship listens, and makes a note of the strongest signal. The bearing denoted by this signal is the bearing of the ship from the station.

In practice, only very short waves of the order of six metres can be used with this arrangement, and ships must be fitted with special apparatus to receive such short waves. This is, of course, a serious drawback, and the system has not come into general use.

The idea of a rotating beam of waves for navigational purposes has however been developed recently by the Radio Research Board on different lines, which permit the use of waves sufficiently long for reception on the ordinary ship's apparatus. A station of this sort was erected recently by the Government at Orfordness in Suffolk, and is now in operation. The aerial consists of a vertical closed loop, rotating at a uniform speed of one revolution a minute, the waves being emitted in the direction of the plane of the loop. A signal of constant radiation is transmitted throughout the whole period of operation, except when the loop is in a north-south or east-west plane, when characteristic distinguishing signals are transmitted. The strength of the signal as received by the ship is a minimum when the plane of the station's aerial loop is at right angles to the ship's line of bearing from the station, and a maximum when the aerial loop comes into line with the bearing. The ship's operator starts a stop watch when he hears one of the characteristic signals, and stops it when the emission is heard weakest. By a simple calculation he obtains the bearing of the ship from the station.

This is the first station of the kind which has been erected anywhere for ship work, and it is too early yet to say whether the system will come into general use, though it has already proved its worth in connexion with the navigation of aircraft up to ranges of about

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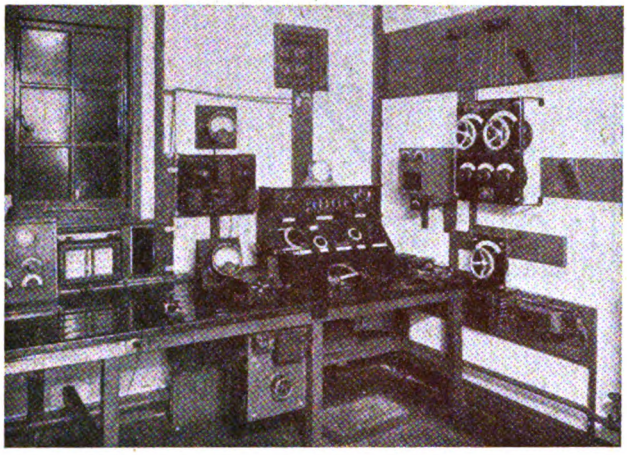
200 miles. The wave used at Orfordness is 1,000 metres.

Stations which emit distinguishing signals as aids to navigation are called wireless beacons, and this particular type of rotating beacon has the great advantage that the ship obtains its bearing by using its ordinary receiving apparatus.



A Directional Receiver at Humber Radio.

All-Round Beacons

Another form of beacon, which is much cheaper to erect and operate, is now used extensively throughout the world. This is an all-round beacon, that is to say, it emits its distinguishing signal automatically at stated times in all directions. A ship in any position within range of such a beacon can, of course, receive the signals, which are sent on a wave of about 1,000 metres, but unless the ship is fitted with a directional receiver it cannot obtain its bearing from the beacon. This fact limits the use of such beacons, as the number of ships fitted with directional receivers is small; in this country about 20 per cent. of the ships which have wireless installations. But, as we have seen in a previous article, the new International Convention for the Safety of Life at Sea stipulates that within the next three years all passenger ships must be equipped with directional receivers, so that the number of ships throughout the world which will be able to make use of these all-round beacons will be materially increased.

Ten of these all-round beacons, operated by Trinity House or local authorities, are already in operation in this country, and more will shortly be erected. Those working are in lighthouses or lightships at Kinnaird Head, Spurn Head, Cromer, Dungeness, Start Point, Caskets, the Scillies, Liverpool, the Skerries, and Conningbeg in Ireland.

Ships which are fitted with directional receivers can obtain bearings up to ranges of between 50 and 100 miles from these stations.

Synchronous Beacons

The stations at Spurn Head and Liverpool also transmit submarine sound signals which, in conjunction with the wireless signals, enable a ship to calculate its distance as well as its bearing by allowing for the difference in the speed of travel of the sound waves and the wireless waves. Sound waves in water travel at a speed of about one nautical mile in one and a quarter seconds, whereas the wireless waves reach the ship, for all practical purposes, instantaneously. The advantage of having such combined signals is obvious, but these stations, which are called synchronous beacons, are of course more expensive to install and to operate than the simple wireless beacons.

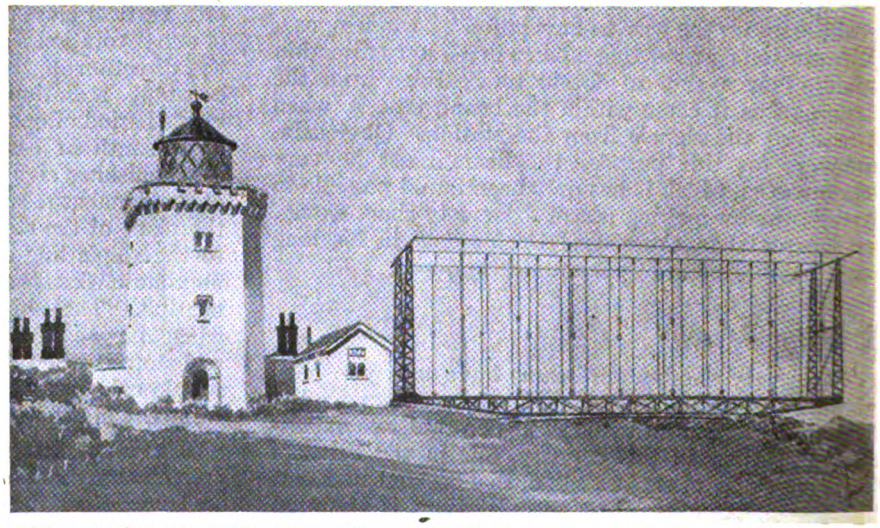
Another interesting type of synchronous beacon is now being tested by the Clyde Lighthouse Trustees. In this case wireless telephony is used, and the words, one, two, three, etc., are broadcast in conjunction with the fog sound signal in such a way that when the sound of the signal coincides with a number heard on the wireless apparatus that number is the number of miles of the ship from the fog beacon. The Trustees already make use of wireless for controlling the operation of acetylene fog guns from a distance, and this is indeed the only application of wireless for this purpose that has yet been put into commercial operation.

These all-round and synchronous beacons are only of use for obtaining bearings to ships which are fitted with directional receivers.

Directional Receivers

There are three main designs of directional receivers at present in use, viz., the fixed double loop, the rotating double loop, and the single loop.

In the fixed double loop system, the aerial consists of two vertical loops in planes at right angles to one



Marconi Company's Directional Transmitter (using a very short wavelength) at South Foreland.

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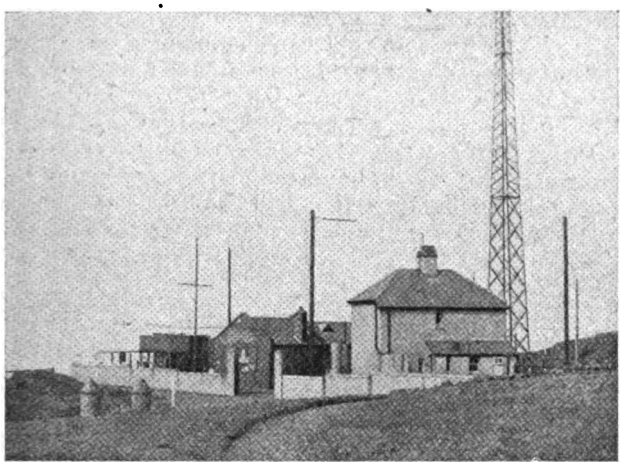
another. The operator rotates a coil in the receiving set and by this means varies the strength of the signals heard in the telephones. The direction from which the signals are coming is determined from the position of the coil when the signals sound weakest.



Portpatrick Radio, showing the short masts for staying out the large loop aerial used for directional reception.

In the rotating double loop system, the aerial is similar, though smaller, and capable of being rotated mechanically from the wireless office. The connexions, too, of the loops to the receiver can be reversed in the wireless office by a simple switching arrangement. The operator listens to the signals and rotates the aerial until he finds a position where reversing the connexions does not affect the strength of the signals. The direction from which the signals are coming is determined by this position.*

In the single loop system, the aerial consists of a small single loop which is capable of being rotated mechanically from the wireless office, and the direction from which the signals are coming is determined from the position of the loop when the signals sound weakest.

In all cases, the bearing obtained is the bearing of the station relative to the direction in which the ship's head is pointing at the time, and depends for its correct interpretation on the correctness of the compass reading when the observation is made. There is no real difficulty in this, and in the latest sets it is arranged for automatically, so that the operator reads off the required bearing on a scale without any need for calculation.

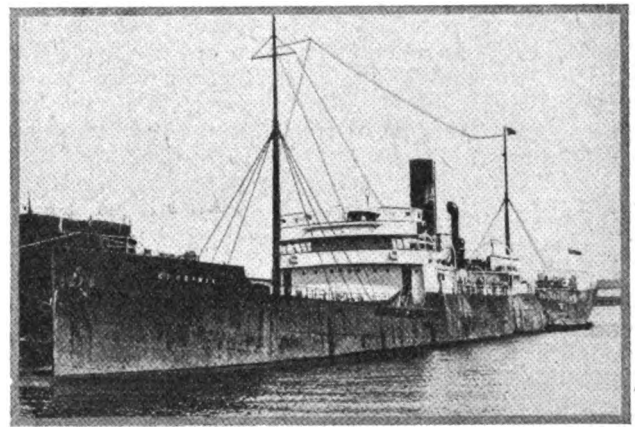
Bearings obtained with any of these systems are, under normal conditions, accurate to within two degrees, which is all that is required for navigational purposes up to ranges of about 100 miles. When conditions are not normal the operator is aware of the fact from the character of the signals received, and in such cases reports the bearings obtained as being unreliable. If, however, the ship is in a position such that the signals received from the station pass along the coast line or over much intervening land, the observations may be unreliable, and the operator may not be aware of the fact, though it is seldom that he will be so vague as to the position of the ship as to place reliance on such bearings.

Ships fitted with directional receivers can, of course, obtain bearings from other ships and from ordinary coast stations. In such cases it is usual for the ship which requires the bearing to ask the other ship or coast station to send its call sign continuously for a minute, which is ample time for obtaining a bearing. In this country the coast station makes a charge of 5s. for each one-minute period of sending.

Direction Finding Stations

All these methods by which a ship can obtain bearings, except in the case of obtaining bearings from the Orfordness rotating beacon, necessitate the ship being fitted with a directional receiver, and, as we have seen, the great majority of ships are not so fitted. To meet the case of these ships to some extent, a number of coast stations throughout the world are fitted with directional receivers for the purpose of taking bearings. In this country the stations at Wick, Cullercoats, the Humber, Niton, the Lizard, Portpatrick and Malin Head are so fitted. These stations are carefully calibrated every year, and those sectors in which bearings may be unreliable, due to the effects of coast lines or intervening land, etc., are published for the information of shipping. In any case, the operator at the station informs the ship if he considers that there may be any doubt about the accuracy of the bearing, so that unless the ship is told to the contrary it may be confident that the bearing given by the station is accurate to within about two degrees.

The procedure is that the ship informs the station that it requires a bearing, and then sends its call sign continuously for one minute. The station observes, with its directional receiver, the direction from which the signals are coming, and signals this bearing to the ship. The stations use the 600-metre wave for this work, with the exception of the Lizard which uses the 800-metre wave, and a charge of 5s. is made for each bearing given. This service is especially useful in foggy weather, and last year these stations gave over 8,000 bearings to ships.



S.S. "Gloxinia," showing (amidships on bridge) small loop directional aerial.

*This system was originated and perfected by our well-known contributor, Dr. J. Robinson.

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So far, we have considered the ship as obtaining a bearing from one station only, but it is obvious that if it is placed so that it can obtain reliable bearings from two or more stations within a very short space of time, it can fix its approximate position from the intersection of these lines of bearings on the chart.

Aircraft

With regard to aircraft, the advantage of obtaining bearings from ground stations is obvious, and all important aerodromes, such as Croydon, Lympne and Pulham, are equipped with directional apparatus. In the aircraft there are serious difficulties in fitting directional receivers as space is so limited and the personnel have so many other things to attend to. Efforts are being made to get over these difficulties, but at the moment aircraft have to rely principally on bearings obtained by ground stations.

Latest Developments

There are several other aids to navigation which utilise wireless apparatus, notably the Leader Cable and the Fathometer, but these are not yet in extensive use. There is also a very important one in process of development, viz., Mr. Baird's Noctovisor.

The Leader Cable is a method of guiding ships in or out of harbours, or through narrow waters. It consists of an alternating current submarine cable laid along the course on which the ship should steer. The ship is fitted with two special receivers, one on either side. When the ship is directly over the cable the strength of the signals received by induction from the cable in each receiver is the same; but when the ship is not directly over the cable the signals in the receiver nearer to the cable will be stronger than in the one further away. The correct course is therefore that on which the signals are received at the same strength in both receivers.

The Fathometer, which was invented by Fessenden, whom we have noted as one of the great American pioneers of wireless, is the latest method of taking soundings from a ship. The rate of travel of sound in water is known, and if a sound is transmitted from the bottom of the ship it will be reflected back from the bed of the ocean. In the Fathometer this reflected sound is amplified by valves, and is made to operate apparatus so that the depth of water can be read directly off a scale. It is a most ingenious arrangement, and will doubtless be used extensively in the future.

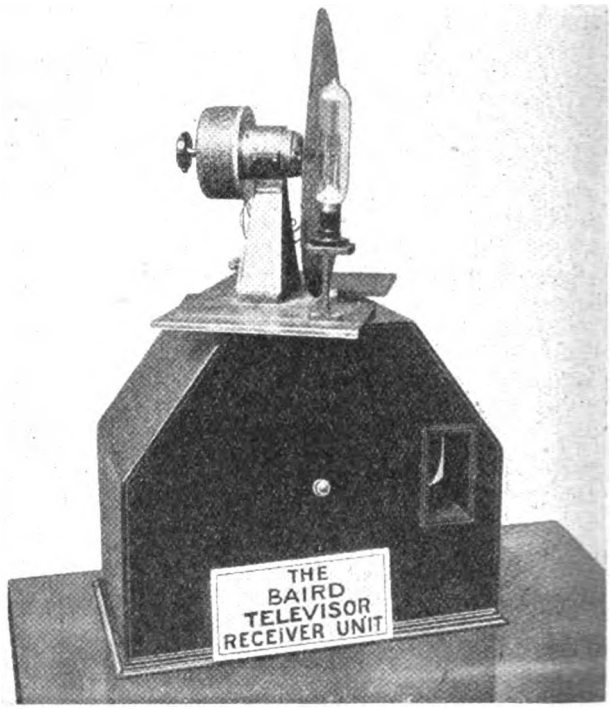
Mr. Baird's Noctovisor depends on the fact that infra-red rays, which are invisible, can penetrate fog far better than visible light rays. A ship could direct a beam of these infra-red rays, and be able to see on the screen of its noctovision receiver objects in the path of the rays, such as the navigation lights on another ship or the light from a lighthouse or lightship.

A recent demonstration given by Mr. Baird with this extraordinarily interesting invention was described in the September (1929) issue of this journal.

ANNOUNCEMENT

Following upon the television demonstrations which the Baird Company gave during the Radio Exhibition at Olympia, we understand they have received many applications from radio firms who desire to manufacture Baird "televisor" receiver units.

In view of the fact that wireless manufacturers are now in the midst of their 1930 programmes and cannot, therefore, be expected immediately to get into production with Baird "televisors" (special machinery being required), the Baird Company have made arrangements for a minimum number of 1,000 complete units to be manufactured and assembled. These units will be marketed through the trade to the public, and



The Baird televisor receiver unit, removed from its case. See accompanying announcement.

it is hoped to begin deliveries during the first week of January.

The Baird unit will be housed in a separate case, and will have no wireless receiver incorporated.

We are informed that whilst actual manufacture is still not the Company's policy, their only reason for departing from it temporarily is in order to facilitate early deliveries.

In this connection we are asked to draw attention to the fact that the constructor's licences which have been issued by Television Press, Limited, were actually licences for the construction within two years of television apparatus according to a particular specification, as described in Nos. 1 to 3, Vol. 1, of TELEVISION, and they do not refer to the Baird "televisor" receivers which will now be put on the market by the Baird Television Development Company, Limited, or their licensees.

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Experimental Television Apparatus

By *A. A. Waters*

PART VII

SINCE writing the last article of this series it has been possible to test all the experimental television receiving equipment already described on the morning transmissions from 2LO. Our results so far have been very encouraging, and I feel sure that experimenters who are lucky enough to have the opportunity of testing their own apparatus on these transmissions will welcome a brief description of our methods, and of the difficulties which we have encountered.

Considering first the type of receiving set required, we find that any set which is capable of giving really good loud-speaker results on an ordinary programme will give satisfactory television reception. By " really good " loud-speaker results is meant a strength of signal which is just slightly too loud to be pleasant in a room measuring roughly 12 feet square.

Suitable Wireless Receivers

Hence, a good " screen grid IV " type of set which is so popular just now will be found quite satisfactory when receiving the Brookmans Park transmissions anywhere round London. Listeners living at greater distances, and finding this type of set insufficiently powerful, will get good results by replacing the two low-frequency stages of the set by the special amplifier described in an earlier article of this series. Our first experiments were carried out using a modification of the well-known Ferranti S.G. IV receiver. The H.F. and detector stages were constructed exactly in accordance with the published instructions, and were followed by the special amplifier referred to above, making a total of five stages. This set gave greater strength than was needed, and was always used with the volume-control turned well down.

Subsequently a four-stage Resistance-Capacity coupled amplifier was constructed, using two Mazda PX 650 valves in transformer-coupled push-pull in the last stage. 200 volts H.T. was found sufficient for this amplifier, which showed some improvement in results when used in place of the transformer-coupled amplifier originally employed. Very careful screening of every stage in iron boxes was found necessary, however, in order to get the new amplifier to work really well; and of the two the transformer-coupled amplifier was the easier to operate.

With the transfer of the London programme to the new transmitter at Brookmans Park, it was found that ample strength was available without the use of an H.F. stage. Hence our experiments were continued using an Anode-bend Rectifier only in front of the R.C. amplifier; and an Osram DEL 610 valve was found suitable for the detector, when using a negative bias of about 16 volts, and an H.T. voltage of 200 applied to the valve through an 80,000 Ω coupling resistance. The signal strength is so great in central London from this transmitter, however, that we expect to get the necessary output for television reception by the use of three valves only, viz., an Anode-bend Detector, an R.C. stage, and a transformer-coupled power stage using our existing push-pull P.X. 650's.

The apparatus was first set up using an existing experimental disc, mounted in the receiver already described in these articles, together with the amplifier, neon filter, and a Ragtheon neon tube. The characteristic Baird television signal was easily tuned in, no reaction being used. For the benefit of those who have not yet heard this signal, I think it is best described as a 12-cycle succession of 360-cycle chirps. The signal is most destinctive when heard on a loud-speaker; it is almost unmistakable for anything else, and once heard, should never be forgotten.

The Image Sound

Incidentally, it is very instructive to notice the change in quality of this note when a subject comes in front of the television transmitter. A roughening is noticeable in the tone of the signal, due to the introduction of a range of higher frequencies not previously present.

On running up the receiving disc, results were immediately observed, and an image of a sort could be held in the field of view without great difficulty. No synchronising gear is fitted to our experimental receiver, but after a little practice it will be found fairly simple to hold the image in the field of view. The experimenter should try to anticipate any drifting of the image upwards or downwards, and aim at varying the speed of his receiving disc to compensate for this drift before the image begins to move too rapidly. Once the image is allowed to race away, difficulty may be experienced in finding it again, and valuable seconds will be lost. It should be born in mind that a stationary image of a very distorted nature can be obtained when the receiving disc is

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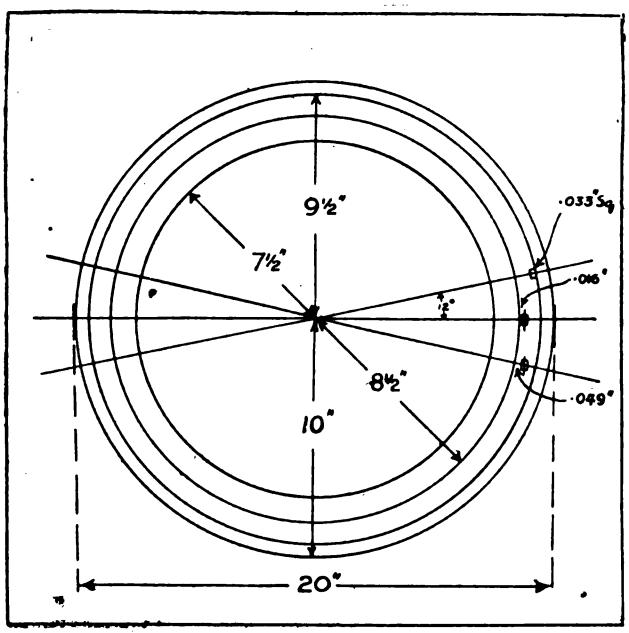

Fig. 1.—The dimensions of the disc used on the Baird transmissions. Only the first two inner holes of the spiral and the last, or outer, hole are shown, in order not to complicate the sketch.

not running at the synchronous speed, but at certain multiples of this speed; hence, whenever a very distorted result is obtained, it is wise to vary the speed of disc and to verify that a better result is not waiting "just round the corner."

First Results

Our first televised images were of a very grotesque nature, the head and shoulders of a subject appearing far too broad in relation to the height. This was expected, however, as we were using a disc chosen at hazard from among a number of experimental ones. No exact information was available as to the dimensions of the disc in use at the Baird transmitter, except that we had reason to believe that it contained a single spiral of 30 holes. This view was confirmed by the fact that the 30-hole disc first tried gave a definite, although distorted, image. Hence a number of 30-hole discs were constructed, with various ratios of length to width of image. One of these was found to give very good results, and probably represents a very near approach to that actually in use by the Baird Company. Hence we offer the constructional details of this disc to our readers as a valuable guide until the actual dimensions are published, and they may construct it with every confidence of getting satisfactory results.

Before proceeding to the description of this disc, however, I would advise experimenters to pay careful attention to the current used to actuate the neon tube. We have found that by careful adjustment of this results were obtained which are not greatly inferior to those shown at the Baird demonstrations given during the wireless exhibition at Olympia. A current between 5 and 20 *mA* will generally be found suitable, and this current should be increased in proportion to the strength of signal which the radio receiver is delivering to the neon tube.

A Word of Warning

And here a word of warning may not be out of place. If the image received is lacking in half-tones, and resembles a shadowgraph in appearance, the trouble is probably caused by too strong a signal being applied to the tube. A similar effect is obtained if overloading is occurring at any point in the set, due, for example, to the use of too small a power valve, insufficient high tension voltage, or insufficient grid bias. *It is useless to expect good television results from a wireless set which is not giving good quality during the normal programmes.* A loss of the higher frequencies will also produce this type of result, and it is interesting to note that results were relatively poor during the first weeks of the Brookmans Park transmission, probably due to the loss of these frequencies in the land line used. Only now during November are we getting such good results again as we obtained at first from the old 2LO transmitter.

The dimensions of the disc used for the Baird transmissions will be found in Fig. 1.

The first step is to obtain a piece of sheet aluminium 24 inches square by 24 s.w.g. (standard wire gauge). Particular care should be exercised in selecting a flat piece of material, otherwise it will cause trouble by vibration, due to its being untrue on the surface. A piece of material of a much thinner gauge could be used if the experimenter has the facilities for cutting out the disc, and in this case the disc may be expected to spin itself true while in use. I do not recommend the thinner material, however, except when one has the necessary tools and experience for cutting it.

The trammels which are used were described in detail in a previous article,* and have proved invaluable for making experimental discs. The diameter now required being 20 inches, the trammels should be set at 10 inches, and the cutting operation should be done on both sides of the material until the tool almost breaks through. A little paraffin oil will be found to be of assistance as a cutting lubricant.

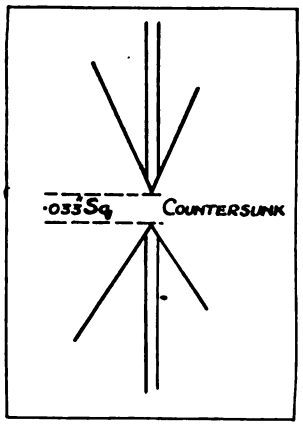

Fig. 2.—Showing how the holes are countersunk.

The marking off should be very carefully done, care being taken with the dividing of the inch into thirty parts. A slight error in this division will show up badly when the disc is in use. The points of the dividers must be kept sharp, and I would advise the use of a magnifying glass. It will be noticed that there are three circles inscribed on the disc; the smaller circle is used to facilitate the use of a small pair of dividers,

(*Continued on page* 498.)

* TELEVISION, July, 1929.

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Aerial and Earth Systems for Reception

By *R. L. Smith-Rose*, D.Sc., Ph.D., A.M.I.E.E.

IN the September issue of TELEVISION I dealt with the effect of local conditions in screening wireless receiving aerials. In view of the importance of the aerial and earth system in the reception of both sound and vision signals it will be worth while devoting another article to some considerations of the manner in which the receiving aerial operates, and of its arrangement to obtain the best efficiency.

The aerial, whether it be of the open wire or closed loop type, is essentially the agent by which the energy of the passing waves is extracted for the purpose of giving intelligible signals to the loud-speaker and televisor. However much the received currents or voltages may be magnified subsequently by the use of valves, the net amount of energy absorbed from the ether is determined by the aerial circuit. To obtain the best results, therefore, in any given circumstances, it is necessary to ensure that the aerial is arranged in such a manner that the maximum possible electro-motive force is induced in it by the incoming waves, and also that the dead losses in it due to its ohmic resistance should be reduced to a minimum.

The manner in which these conditions can be met in any given case depends upon what limitations, if any, are imposed on the aerial and earth system from other considerations. For example, in one situation the space occupied by the system may be immaterial, and the aerial will then be limited in the matter of its length to 100 feet on the ordinary receiving licence. In other situations both the height and length of the aerial may be limited, and the problem is then reduced to that of utilising to the best advantage the space available.

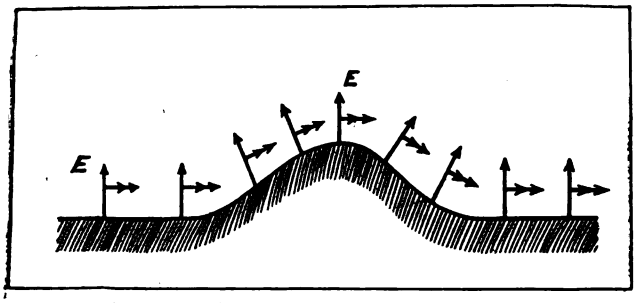

Fig. 2.—When the slope is not too abrupt the direction of travel of a wireless wave follows the contour of the ground.

Let us first take the case of getting the maximum E.M.F. into the aerial. In an elementary study of the travel of wireless waves over the earth's surface, the earth is usually assumed to be a perfect conductor,

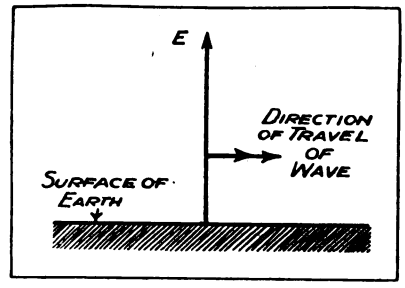

Fig. 1.—Direction of the electric force E in a wireless wave travelling horizontally over a perfectly conducting earth.

and we are informed that the electric lines of force must always be perpendicular to such a conductor. Therefore, the wireless waves are represented as travelling horizontally along the earth with the electric force perpendicular to it; for open ground that is sensibly horizontal the state of affairs is as represented in Fig. 1.

Effect of Hills

Where the ground is not flat, but is subject to the undulations of hilly country, the above boundary condition must still obtain. Thus for a hill or mountain of moderately gentle slope, the manner in which a wireless wave surmounts it is shown in Fig. 2. If the change in slope is very abrupt, as in the case of a precipice, the state of affairs is not quite so straightforward as that represented, and other secondary effects must be taken into consideration.

In the next stage of the study of wireless waves it is appreciated, sometimes very forcibly, that the earth is, after all, not a perfect conductor; in fact, that it is a very bad conductor as compared, for example, with copper. This departure from perfection was shown theoretically by Zenneck to result in a tilting forward of the lines of electric force as the wave progresses, in the manner shown in Fig. 3.

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If this forward tilt is at all large, it is evident that a vertical aerial will not have such a large E.M.F. induced in it as an aerial which is arranged approximately parallel to the electric force, as in Fig. 4 (a). Further, the direction of the slope of the aerial will depend upon the direction from which the waves are arriving. For instance, a wave arriving from the left (*L*) will induce a greater E.M.F. in an aerial sloping as in Fig. 4 (a) than in one arranged as in Fig. 4 (b); while if the wave is approaching from the right (*R*) the state of affairs will be reversed.

Although this forward tilt of the wave-front was predicted by Zenneck over twenty years ago, no experimental verification of it was made until quite recently, and our knowledge as to the possible values of the tilt in any practical cases has been very indefinite. It was known from the theoretical analysis that the angle of the tilt would increase as either the wave-length or the conductivity of the earth was

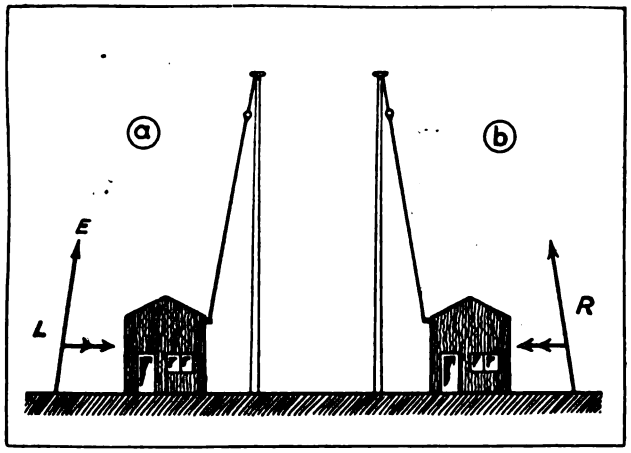

Fig. 4.—The E.M.F. induced in an aerial is greatest when the wire is parallel to the direction of the electric force.

reduced, but no satisfactory data were available as to the effective conductivity of the earth's crust at wireless frequencies.

During the past few years, however, many experiments have been carried out in different parts of England in which the inclination of the electric force to the vertical has been directly measured for various wave-lengths. The results show that for wave-lengths in excess of 2,000 metres the electric force in waves arriving under any normal conditions is never inclined at an angle of more than 1 degree to a line drawn perpendicularly to the earth's surface at the place in question. As the wave-length is diminished this angle increases to a value in the neighbourhood of 3 degrees for a wave-length of 300 metres, while for shorter wave-lengths the angle may reach about twice this value.

In the course of these experiments some measurements were made on the side of a hill sloping at 16 degrees to the horizontal, and it was verified that the waves were travelling sensibly in the manner depicted in Fig. 2. It is evident from these results that in order to get the maximum E.M.F. induced in an aerial on wave-lengths in or above the normal broadcasting band the major portion of the aerial should be arranged to be as far as possible vertical; or rather, perpendicular to the average direction of the ground in the immediate neighbourhood.

The slope of the wave-front of 3 degrees above mentioned may be interpreted in another way as indicating that the strength of the horizontal component of the electric force is only about five per cent. of the strength of the vertical component. Hence if a given length of wire be arranged first vertically and then horizontally, the E.M.F. induced therein will be twenty times as great in the first case as it will in the second. There is an important difference between the two cases, however, for with the vertical wire the E.M.F. is the same for all directions of arrival of the wave, whereas with the horizontal wire the E.M.F. varies with the direction of arrival of the waves.

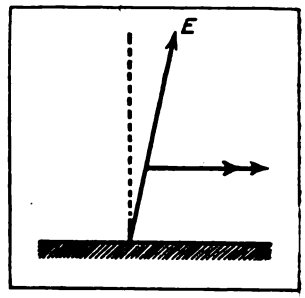

Fig. 3.—Tilting forward of the electric force due to imperfect conductivity of the earth's surface.

This effect can probably be best understood by supposing the vertical and horizontal wires joined together to form an inverted ⅂ aerial as in Fig. 5. A little consideration of the case when the waves are arriving from the left hand side (*L*) will show that the E.M.F.'s induced in the two portions of the aerial depicted in Fig. 5 (a) will be in opposition as indicated by the arrows; while with the aerial reversed as in Fig. 5 (b) the two E.M.F.'s are assisting each other. If the two aerials are rotated through a right-angle so that the horizontal portions are perpendicular to the direction of arrival of the waves, no E.M.F.'s will be induced in these portions, and the vertical parts of the aerial will alone be operative in receiving an E.M.F. from the waves.

Directional Properties of Receiving Aerials

These considerations, taken in conjunction with the numerical results quoted above, indicate that an

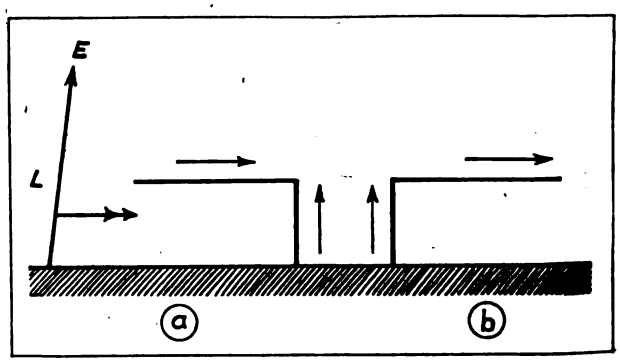

Fig. 5.—E.M.F.'s induced in two inverted ⅂ aerials by the vertical and horizontal components of the electric force of the wave approaching from L.

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inverted ⅂ aerial can have appreciable directional receiving properties only when the wave-length is moderately short and when the horizontal length of the aerial is several times its vertical height. In some

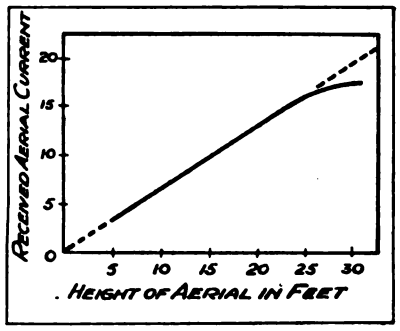

Fig. 6.—Graph showing the relation between the height of an inverted ⅂ aerial 100 feet in total length and the received current measured in arbitrary units.

direct measurements which have been made of the relative currents obtained in inverted ⅂ aerials orientated in different directions with respect to the transmitter, it was shown that with an aerial 20 feet high and of 80 feet horizontal length used on a wave-length of 365 metres, the difference in current received by the aerial in its worst and best positions (*i.e.*, as indicated in Fig. 5 (a) and (b) respectively) was about twenty per cent. of the mean current. The most favourable position was, of course, that in which the free end of the aerial pointed away from the transmitting station Fig. 5 (b).

In considering the importance of the directional effect in this case, which is one that might easily arise in a broadcast receiving aerial, it is to be noted that the same increase in current could have been brought about by increasing the height of the aerial by only 3 or 4 feet. If the case is carried to the extreme in which the height becomes negligible compared with the horizontal length, we see that while an appreciable E.M.F. can be received, such an aerial will have very marked directional properties. This deduction has been verified from time to time in experimental work which has been carried out on horizontal aerials laid on the ground.

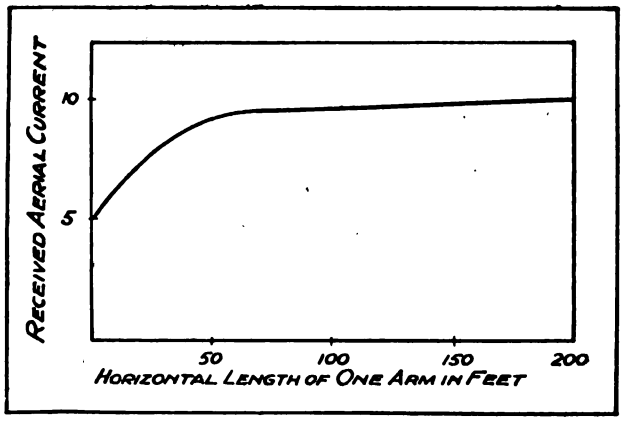

Fig. 8.—Received current obtained in a T aerial of height 60 feet, with varying length of the horizontal portion.

General Conclusions

The general conclusions which may be drawn from the discussion in this section are therefore as follows. With a view to securing that the maximum E.M.F. is induced by the arriving waves, a receiving aerial should be erected with its vertical height as great as possible. Except on the shorter wave-lengths and with long, low aerials, the directional effect in reception is not of primary importance; but if other conditions permit, the greatest efficiency will be gained by arranging that the free end of the aerial points away from the transmitter.

To confirm and extend the conclusions reached in the last section a series of measurements made with different aerial arrangements may be quoted. The use of a valve voltmeter in conjunction with a mirror galvanometer enabled a direct interpretation to be made of the current induced in the aerial by the carrier wave from the London broadcasting station at a distance of about 10 miles. In the conduct of the experiments it was decided to apply the limiting

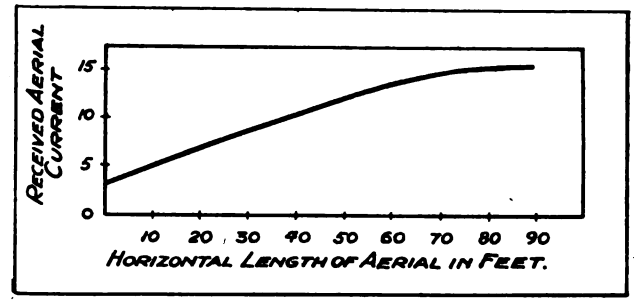

Fig. 7.—Effect on the aerial current produced by lengthening the horizontal portion of the aerial, the height being fixed at 25 feet.

condition that the total length of the aerial should not exceed 100 feet, and the experiments were made partly with a view to ascertaining in which way this length of wire could be used to the best advantage.

In the first case, using a single wire aerial of the above total length, measurements were made of the received current when the aerial was given heights varying from 7½ feet to 30 feet, the remaining length of wire being arranged horizontally in a fixed direction. The results obtained are shown in Fig. 6, from which it is seen that up to a height of about 20 feet the received current increases uniformly and is proportional to the height. Beyond this the current still increases, but not so rapidly, and the results indicate that if the height was made about 40 feet any increase in this height would produce only a small percentage increase in the received current.

In the next experiment the height of the aerial was fixed at 25 feet. With a total length of wire of 100 feet, this leaves an available length for the horizontal portion of 75 feet. It was then desired to ascertain what was to be gained by any increase in this horizontal length, and also how much would be lost should other circumstances, such as limitations of space, preclude the utilisation of the full 75 feet. The results of measurements on these lines are shown

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in Fig. 7. It is seen that as the length of the horizontal part is increased from zero to about 40 feet, the received current increases in a linear manner. Above this point the rate of increase falls off very considerably, and beyond the permitted length of 75 feet the increase in received current is almost negligible.

This optimum ratio of horizontal length to height of about three to one has been confirmed by other experiments in which the total length of aerial employed was not restricted to 100 feet. In Fig. 8 is given the results of similar measurements of received

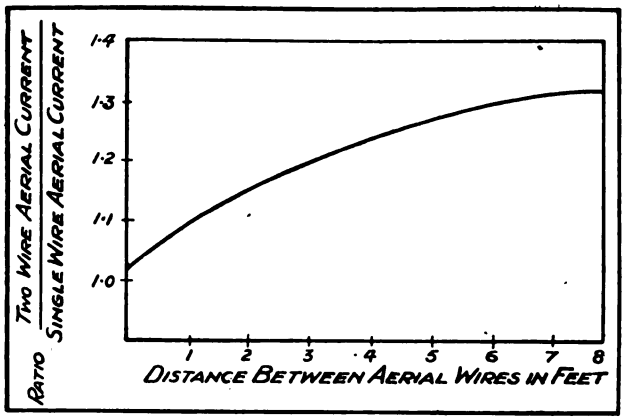

Fig. 9.—Curve showing the effectiveness of a twin wire aerial with varying distances between the wires.

current on a T aerial 60 feet high and with a horizontal length up to 200 feet. It is seen that in this case the current ceases to increase after the horizontal portion has reached about 180 feet in length. All these experiments refer, of course, to the medium broadcast band of wave-length only.

Use of Aerial with Several Wires

Having thus investigated the effect of height and length of the aerial, the next point was to ascertain what advantage is to be gained by using more than one wire in the horizontal portion of the aerial, and if two or more wires are used, at what distance apart these should be. For this set of measurements an aerial was constructed in the form of two stranded wires of No. 3/19 S.W.G. enamelled copper 75 feet long, supported at a height of 25 feet above the earth screen employed therewith. Successive measurements of the received current were made while the distance between the wires was reduced in steps from 8 feet to zero; and finally a single wire of No. 20 S.W.G. was substituted for the two adjacent wires.

The results are shown in Fig. 9 in terms of the ratio of the current received on the aerial to the current received on the single-wire aerial. It will be seen that if two wires are used they should be at least 6, and preferably 8, feet apart. Even with this spacing, however, the increase in current obtainable over that on a single wire aerial is not large, being about thirty per cent. in the case quoted. Using the full 8 feet spreader space, further measurements made with three or four wires arranged symmetrically showed that nothing was to be gained by increasing the number of wires in this way.

Effect of Earthing Resistance

It should be pointed out, in conclusion, that all of the above measurements were carried out on the aerial used in conjunction with a fairly efficient earth-screen, the lowest actual resistance of the aerial circuit in the last case being about 11 ohms. If, as may easily be the case with the average aerial employed for broadcast reception, a much higher resistance were associated with the earthing arrangement, then it is evident that any improvement in the aerial alone will have less effect on the magnitude of the received current.

As an illustration of this point the case of the last measurement described above may be cited. The substitution of a single wire of No. 20 S.W.G. for two stranded wires of No. 3/19 gauge made an almost negligible difference in the received current, although the resistance of the former is nearly eight times that of the latter. The explanation is, of course, that the actual ohmic resistance of the aerial wire in this case is only one or two ohms, even at high frequencies, and that the change in the total resistance of the aerial circuit produced by the substitution is practically negligible, on account of the fact that the effective resistance of the earth connection may be anything from 10 to 50 ohms. In the absence of a somewhat elaborate earth screen or counterpoise which can be made to have a fairly low resistance, the best type of earth connection available to the average householder is undoubtedly the main water pipe.

Experimental Television Apparatus.

(*Concluded from page 494.*)

and the circumference of this circle is used as a fixed reference point.

The intending constructor will need a suitable rule for this particular job, since 1/30th of an inch is not a measurement used in common practice. I found that this measurement is in use by surveyors, and after trying a number of rule makers for such a steel rule, I at last obtained an ivory-edged one from Stanley & Co., 286, High Holborn, London, W.C.1.

The drilling of the holes should be done with a number sixty drill, using a very light hand brace, and paraffin as a lubricant.

These holes should next be countersunk on both sides of the disc, so as to leave a sharp edge, as indicated in Fig. 2. We next come to the operation of squaring the holes, and as it is a difficult and delicate job to make a drift of this size, I would advise the use of the tag end of a small Swiss file. If this is just pushed into the holes for the correct distance in each case, one will be surprised at the excellent square obtained.

In my next article I hope to describe the construction of a phonic wheel synchronising device suitable for use when receiving the Baird transmissions.

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The Chemistry of Tungsten

By *W. F. F. Shearcroft*, B.Sc., A.I.C.
Fellow of the Television Society

IN the early history of the progress of wireless transmission, we find that Edison applied for a patent for a diode valve for the purpose of controlling the voltage of electric lighting systems. The invention does not seem to have received very much attention, or practical application. That, however, is typical of our hobby. The greatest inventions have been neglected when first they appeared.

In 1904 Sir (then Professor) 'Ambrose Fleming applied for a patent for a somewhat similar instrument, or rather for the discovery that "if two conductors are enclosed in a vessel in which a good vacuum is made, one being heated to a high temperature, the space between the hot and cold conductors possesses a unilateral electric conductivity."

In 1909 Feming obtained a patent for a diode, in which the filament was made of *tungsten*. From this stage onward the history of the subject is too well known to need further mention, but no small part in that progress has been played by the element tungsten.

Tungsten is an element in the sixth group of the periodic table and its position with reference to other members of the group is shown in the table below :—

Group VI.

A	*B*
Cr	O
Mo	S
W	Se
Ur	Te
—	Po

It belongs essentially to the chromium sub-group, the members of which exhibit the usual gradation of properties. Some of the more important physical properties of the group are tabulated below :—

Element	Chromium	Molybdenum	Tungsten	Uranium
Symbol ..	Cr	Mo	W	Ur
Atomic weight	52·01	96	184	238·2
Specific heat	0·1208	0·0647	0·0358	0·0280
Melting point	1,550° C.	2,450° C.	3,267° C.	1,850° C.
Boiling point	2,200° C.	3,200° C.	4,700° C.	2,450° C.
Density ..	6·9	9–10	19	18·7

It is of interest to note that tungsten precedes that most interesting of elements uranium, which, by its radio-active properties, first started off the work on atomic structure, which has been so useful in both theory and practice.

The ores from which tungsten is now obtained were at one time thought to be tin ores. Scheele, in 1781, differentiated between the elements, and in 1783 the metal was first obtained. *Wolframite*, from which the element takes its symbol, is the best known and most widely distributed ore. It is a mixture of iron and manganese tungstates, which may be represented by the formula, not supposed to be exact, $(FeMn)WO_4$. It is a black or brownish-black mineral occurring in the Urals of Russia, Saxony, New England, Colorado, New South Wales, Cumberland, and Cornwall. There are various forms of the mineral, which are usually associated with tin ores. An average composition is :—

FeO = 18·96 per cent.
MnO = 4·67 ,,
WO_3 = 76·37 ,,

Ferritungstite (Fe_2O_3, WO_3, $6H_2O$) is a brownish mineral found mainly in Washington State. *Scheelite*, calcium tungstate ($CaWO_4$), is widely distributed, and is a yellowish or pale-brown mineral, with a waxy lustre. It is most favoured for the production of the element. *Tungstite*, essentially an oxide of the metal, is found in British Columbia.

Oxidation

The extraction of the element from its ores divides roughly into two stages, the first of which is to convert the ore into tungsten oxide (WO_3). The mineral concentrates are crushed and the impurities separated, a magnetic separation process being employed. An oxidation process follows, where the ores are rotated in the air. From this mixture of oxides the tungsten oxide is dissolved out by heating under pressure with a suitable alkaline solution. An ammonia solution results in the formation of a solution of ammonium tungstate, from which crystals of this salt can be obtained. On heating, these are transformed into a canary-coloured, amorphous powder, which is essentially the required oxide.

The oxide is then reduced to the element by heating to red heat with carbon, or by treatment with pure hydrogen.

The element itself is known in a silvery-white form

(*Continued on page* 502.)

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Sydney A. Moseley *on* a New

IT seems that I am no longer to play a lone hand, and time, too, don't you think? There has come from the north—and certainly the north should provide champions for Mr. Baird!—a redoubtable fighter—a new Richmond—who has been helping to make things hum. I refer to Mr. W. Barrie Abbott, a well-known chartered accountant of Peebles, whose letters I quoted in last month's issue of TELEVISION. These quotations, by the way, were amplified by the publication in full of other correspondence which he had with Sir John Reith and other eminent persons.

There has now come to my hand a further letter which Mr. Abbott has addressed to my esteemed friend, Captain P. P. Eckersley, late of the B.B.C. and now of the Gramophone Co., and I think it will add not only to the interest of the subject but to the joy of nations for me to deal with this last salvo from bonnie Scotland.

Evading the Point

"Dear Sir," writes Mr. Abbott—though by this time I should have thought that the association should have become more friendly—"I thank you, etc. . . . , *but I think you evade the main point of my correspondence*, which is that your whole attitude towards British television has been antagonistic." There, there, is not that too unkind of Mr. Abbott? He is presumptuous enough to infer that the gallant Captain would evade the main point. Now there is one thing which is going to hurt the well-known engineer more than anything else. "P. P.," as we who are his admirers refer to him, is bold even if he is bumptious; he is not afraid of his views, and although I have charged him with a good many things I should hesitate to add intellectual cowardice to them. Indeed, his views are so astonishingly original that he would be forgiven if he were a little more reticent concerning some of them. However, Mr. Abbott will have to answer this as soon as his letter catches the eye of his intended victim. I pity him.

Mr. Abbott goes on to say: "Your articles, in my opinion, were written in a jeering and supercilious way, and wherever possible, you introduced the implication that American and other foreign television investigators were ahead of British television, and you failed to give credit to the work being done in this country. You admit that Sir Ambrose Fleming is a better technician than yourself, but it is obvious that you still consider that your own opinion carries greater weight than his."

Now we are nearer the mark. You will recollect that long ago I suspected the gallant Captain of being somewhat superior, not to say supercilious, and it was this unfortunate attitude of mind that brought about a *contretemps* which, in his heart of hearts, he must now bitterly regret. To be perfectly frank and fair, as I always hope to be, I do not remember that Captain Eckersley has ever suggested that American and other television investigators were ahead of British television; honestly, the point of British leadership has never been in doubt. British television took the lead from the first and kept it, although, by the nagging and obstructionist attitude of the authorities in London, Mr. Baird was held up while his rivals forged ahead. I pointed all this out to the invincible Peter; but he remained his calm, confident self, being then, as it happened, Chief Engineer of the B.B.C. And naturally his views were not to be disregarded by those who employed him.

"What is Coming over Him?"

And now after all Captain Eckersley admits that Sir Ambrose Fleming is a better technician than himself! What is coming over him? Are we losing the old spirited "P. P." ? Is there in his stead an engineer who is finding his normal level? Has he become merely fallible?

Incidentally, I should like to pay a tribute to Sir Ambrose for the unfailing and unwavering support that he gave to television from the very first; at any rate there was no doubt in Sir Ambrose's mind, and he was equally as bold as Peter in letting the public know it.

Now the next point in Mr. Abbott's letter to Captain Eckersley is of particular interest to me. He states that Sir Ambrose's opinion "is backed up by other technicians and prominent commercial men representing certain companies of Germany."

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Richmond

It is quite true that " these companies consider television sufficiently advanced commercially to warrant their joining with the Baird Company to form a syndicate to place it upon the market. Commercial ' televisors ' are actually being placed on the market by these companies, whose names and reputations carry infinitely more weight than any purely individual opinion."

Significance not Appreciated

Perhaps I may amplify this statement, particularly in view of the fact that the full significance of this powerful German movement has not been appreciated in London. Since I had something to do with the formation of the Fernseh A.G., I may say that it was only after the closest inspection of the Baird system, and with a full knowledge of other systems, that these experts—one on motors, one on radio manufacture, and a third on optics—agreed to form a company with the British Company. The managing directors of these companies certainly *did* consider television sufficiently advanced commercially to warrant their beginning to manufacture commercial " televisors." I emphasise this because, even to-day, so-called commercial magnates, who have not had the advantage of a study of the situation, still believe television to belong to the realm of fiction. As one who had the pleasure of meeting these German experts on several occasions, I can testify that, *unless they were absolutely certain of the commercial possibilities of television, not one of them would have risked his reputation*, and certainly not risked the finance of his company.

It is true that the first question asked me in Germany when I reached there was: Why does the B.B.C. not permit you to broadcast your television system ? That wanted a lot of explaining away, I admit, but the Germans are very patient people and do not jump to conclusions, and in spite of the undoubted influence of powerful opposition I was able to convince them of the realities of the situation, and this, backed up by actual demonstrations and examinations of the Baird apparatus, resulted in the formation of what has become an historic company.

Readers will recollect that I prophesied that Germany would be the first country to broadcast television officially. It was not very long after my arrival in Berlin that I realised how true this forecast was likely to be, and Mr. Abbott is correct in chastising the gallant Captain for helping a foreign country to be first in the race to broadcast television. However, let me add that the B.B.C. has now made good by extending the facilities originally offered to the Baird Company. Here I will content myself by quoting the remainder of Mr. Abbott's interesting letter.

That " Toy " Business

" It is interesting to note that you keep reiterating the phrase ' a mechanical toy.' Almost exactly the same phrase was used in the early days of the telephone. It was called an ' electrical toy,' and its inventor was chased downstairs by the self-satisfied bureaucrats of his day.

" The object of sending television through the ether is to provide facilities for the great body of amateur experimenters in the country, so that they themselves can make their own experiments on the reception of these transmissions, and in so doing there can be no doubt that they will evolve improvements and novel inventions, just as has been the case with broadcasting, where much valuable work has been contributed by the amateur experimenter, and this valuable work could never have been possible if broadcasting had not been in operation, and the amateur given an opportunity of experimenting with reception.

" The television broadcast transmissions will give this opportunity to the amateur experimenters, a vast body, and a body of workers which deserves

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every encouragement. You ignore this point. The first broadcast transmissions of telephony and the first broadcast receivers well merited your contemptuous observations of 'electrical toys.' I can myself, well recollect the appalling travesty of speech and music which issued from these early wireless receivers, but let us look at the results which these early experiments have led to, and how much the improvements are due to the work of individual amateurs, and the push and impetus given to the industry by the efforts of these individual amateurs.

A Terrific Fight

"It is beyond all doubt that television is having a terrific fight to establish itself in this country and that enormous powers are being employed to retard or subvert it. The following quotation from *Vox* is significant: 'It is well known that the editors of a certain group of newspapers have standing orders to print nothing but discouraging and adverse news and comments on television.' That there is some truth in this staggering accusation might be inferred from the fact that when the Prime Minister himself recently broadcast a speech in which he greatly praised television, the leading newspapers suppressed the part dealing with this subject. Do you not consider such a state of affairs appalling? I am sure that in your heart of hearts you do, and that quite well you know that I have the right end of the stick in this controversy.

"In your last letter you say: 'Of course I may be hopelessly wrong, I may be talking the most appalling nonsense.' I am afraid that I cannot reconcile this admission with your former claim to base your case on 'facts, only facts, and nothing but facts.' But no matter how we have differed in the past, I do sincerely hope that you will now join with me in my humble fight for justice not only to a marvellous British invention but also to one of nature's true gentlemen, that brilliant but modest genius who until now has received such shabby treatment from his own countrymen."

The Truth about Television

Mr. Abbott's reference to *Vox* is true enough, and no doubt he has now seen the first of my own articles in that paper, retailing the truth about television.

There you are. Mr. Abbott and I will probably find the field left to ourselves. I do not see that Captain Eckersley has retorted to the article I contributed to last month's TELEVISION. No doubt, the situation is becoming more placid—far too placid for a journalist like myself who lives and thrives on excitement. Cannot I induce my friend "P. P." to come out with another tirade, or has he lost heart altogether in face of realities, and retired from the field of controversy? I trow not!

EXPERIMENTAL work. Inventors' models. Scanning discs any size to drawings. JOHN SALTER, Scientific Instrument Maker. Established 1896. Featherstone Buildings, High Holborn, W.C.1.

Chemistry of Tungsten.

(*Concluded from page* 499.)

which is very similar to polished platinum in appearance, as a crystallised form and as a grey powder. It is a hard substance: 6·5 to 7·5 on the scale of hardness (diamond=10·0). It has a high melting point (3,267 ± 30° C.), and boils at nearly 5,000° C. The specific heat is 0·0358. The coefficient of expansion is $4{\cdot}2 \times 10^{-6}$ from −100° C. to 0° C. and $4{\cdot}6 \times 10^{-6}$ from 0° C. to 500° C. Tungsten is very incompressible, having in fact the lowest compressibility that has been studied so far.

Tungsten is not oxidised appreciably when heated in the air below red heat, but coloured films are formed on the surface. It combines directly with carbon, silicon and boron when heated with these elements in the electric furnace. With sulphur and phosphorus it has no direct action. It will decompose water at red heat, but exhibits great resistance to attack by acids.

As a Filament

It owes its great use as a filament in electric lamps to its high melting point and non-volatility. Its use and life as a filament is considerably improved by the addition of a small percentage of thoria—up to 1 per cent. being added in practice.

The filaments are made by a variety of processes. Mechanical drawing is used, when a wire of the element is forced slowly through a thin orifice at a temperature of 2,000° C. This process, if correctly carried out, produces a single, elongated crystal. Compression of a paste of tungsten mixed with various organic compounds, with subsequent carbonisation, sintering and shaping, is another method. Tungsten in the colloidal states has also been used, and filaments can be formed by exposing a glowing filament of carbon in an atmosphere of tungsten chloride mixed with hydrogen. This produces a coating of tungsten around the carbon core. Many other processes have been tried, and some of them are in use.

In an ordinary evacuated lamp it is safe to let the temperature rise to 2,130° C. with a tungsten filament. Above this temperature volatilisation occurs, and results in the deposition of tungsten on the glass of the lamp, and the consequent diminution of its brilliancy. This defect has been overcome to some extent by coating the inside of the bulb with various substances, which appear to dissolve the deposited tungsten.

In addition to filament construction, tungsten finds a use as a substitute for the more expensive platinum. Its hardness, good heat-conducting properties, and high melting point make it suitable for electrical contacts, and arcing points. It is used as a target for X-ray tubes, and forms an important series of alloys, of which tungsten-steel is the best known.

It forms a series of peculiar compounds which result from the reduction of certain tungstates, and are known as *tungsten bronzes*. These are very metallic in appearance, and vary from vivid golden-yellows to violet in colour, and are used as substitutes for bronze powder.

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The Nature and Properties of Light

PART I.

By *H. Wolfson*

THE nature of light was a problem which gave rise to much speculation among the ancient philosophers. Plato and Aristotle, to mention but two names, were firmly convinced that light was a property of the eye, and the perception of objects and scenes was supposed to be achieved by virtue of certain invisible "tentacles," which stretched between the eye and the object, thus enabling the individual to feel or perceive the object in question.

Needless to say, theories of this sort had no physical foundation, and as soon as people realised the absolute necessity for backing up speculative reasoning by experimental data they were discarded as useless and impracticable.

The Corpuscular Theory

The most important of the theories in vogue about the middle of the seventeenth century was the corpuscular theory. Among the most ardent supporters of this theory was Sir Isaac Newton, whose name will always be world famous for his theory of gravitation, and other works which so firmly laid the foundation stones of modern mathematical and physical science.

According to this theory, light consists of a host of particles of infinitesimal size, moving with enormous velocity. It was imagined that these particles were emitted from every luminous body, in a similar manner to projectiles issuing from a gun. The force of the impact of these material particles on the retina of the eye produces a sensation which we term light.

The path of these particles is the same as the path of a projectile emitted under similar conditions, that is, the particles move in straight lines, so long as they are travelling through space. On reaching the surface of a material body the path becomes modified, and it should be noted carefully that this modification must needs depend upon the nature of the body.

If the surface be a reflecting one, then the corpuscles will experience a repulsion normal to the surface of the body, so long as the particles remain within a small distance of that surface. The path of the corpuscles, once perfectly straight, resolves itself into a curved path when the corpuscles reach the surface, and the repulsion of the particles, after neutralisation of the perpendicular component, becomes reversed. Thus we see that the initial and final paths are straight lines, which are inclined at equal angles to the normal at the surface of the reflector (Fig. 1).

The next case should be carefully noted, as it is here that an opportunity arises to test the veracity of the theory by an experimental method. Consider Fig. 2; let the path of the corpuscle be as shown. We suppose the upper medium to be less refracting than the lower one, which is transparent to light. A typical example of this case would be air and glass. We have to split the velocity of the particle up into what is known as the horizontal and vertical components. The component of the velocity which lies parallel with the surface will naturally remain unaffected since it suffers no change of medium.

The case of the component which is at right angles to the surface, and which we denote by the term the *perpendicular* component, is different, however. This will have its velocity increased as it passes through the thin layer on either side of the surface, shown in the diagram by dotted lines. After traversing this layer the velocity is supposed to undergo no further change. If i be the angle which the incident light makes with the normal and r the angle of refraction, and we assume the velocities in the upper and lower media to be v and v^1 respectively, then the volocities of the component parallel to the surface will be $v \sin i$ before refraction, and $v^1 \sin r$ after refraction.

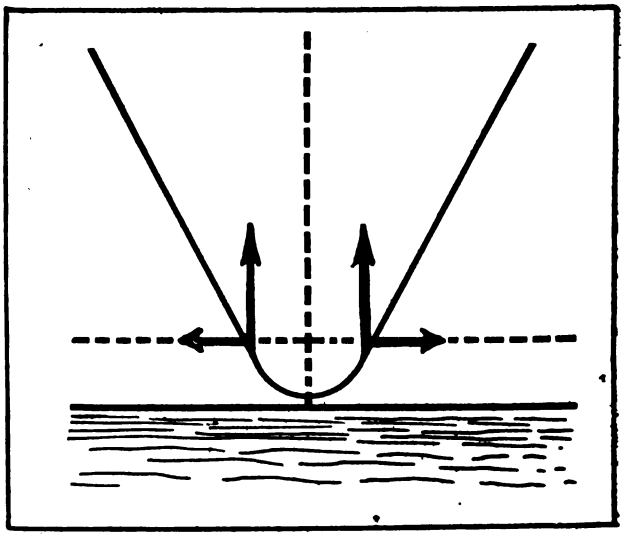

Fig. 1.—Reflection according to corpuscular theory.

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Applying Snell's Law, which states that sin i/sin r is a constant, we see that this ratio in our case is v^1/v. But when light is refracted from a rarer medium (air) to a denser medium (glass) the ratio sin i/sin r is greater

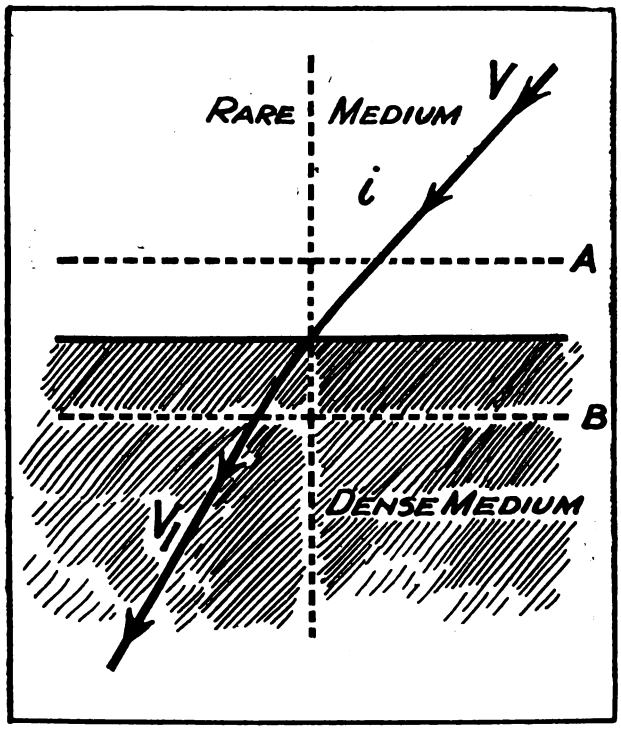

Fig. 2.—Illustrates refraction on the corpuscular theory. Note that the path of the corpuscles is curved between A and B.

than unity. It follows then that the ratio of velocities v^1/v must also be greater than unity.

We arrive, therefore, at the result that "in the denser medium the velocity of light must be greater than in the rarer one." Here, then, is an opportunity to apply an experimental method to the verification of the corpuscular theory. Foucault, the famous French physicist, about the middle of the nineteenth century, carried out a series of experiments in which he proved conclusively that light travels more slowly in water than in air. But water is a medium which is optically denser than air, which is taken as the standard of optical density, with a value of unity.

The corpuscular theory, which till this late period still exercised a considerable influence in the realm of physical thought, was now shown to be absolutely untenable. Nevertheless it still retained a few adherents, who realised the difficulties with which Huyghens' Wave Theory had to contend.

It is interesting to note that Sir Isaac Newton, in this connection, had advanced a theory which was supposed to remove any doubts which might and did arise through experiments such as those of Foucault, more than a century before. His well-known theory of "fits" is sufficiently interesting and amusing to find mention here.

Newton assumed that at the surface of separation of any two media the corpuscles of light are subject to "fits" of easy refraction and reflection. He said: "When a ray of light falls on the surface of a pellucid body, and is there reflected or refracted, may not waves of vibrations or tremors be thereby excited in the refracting or reflecting medium at the point of incidence and continue to arise there, and be propagated from thence, and are not these vibrations propagated from the point of incidence to great distances? And do they not overtake the rays of light, and by overtaking them successively do they not put them into fits of easy reflexion and easy transmission described above? For if the rays endeavour to recede from the densest part of the vibration they may be alternately accelerated and retarded by the vibrations overtaking them." This quotation from Newton's book "Opticks," published in 1750, gives us an insight into the way in which great scientists were ready to formulate minor theories (which to us appear childish and ridiculous) in order to preserve a major theory which they held in great regard.

The only alternative theory which suggests itself, when we are compelled to abandon the corpuscular theory, is that light must consist of some type of waves. We know, however, that any form of wave-motion whatsoever requires some continuous elastic medium for its transmission. We on earth receive light from the various heavenly bodies, such as the sun, moon, and stars. There must exist in space, therefore, some such medium which is capable of transmitting the waves.

Does the Ether Exist?

The term "Luminiferous Ether" is used to designate this medium. Here again we are up against the old problem that our whole arguments depend upon the existence of an invisible, all-pervading thing, of whose real identity we are unaware and whose presence we are unable to verify. Indeed, there are to-day those who discount the existence of the Ether of Space, and the late Dr. Steinmetz was one of those who was fully convinced that its existence was not essential to the proving of the wave theory of light, and the explanation of the phenomena connected with the transmission of Radio waves. Be that as it may, we are forced to admit, that although we are unable to verify the presence of this all-pervading ether of apace, we cannot abandon it in the present state of our knowledge.

A few words as to the properties which our ether must possess will not be out of place. First and foremost, the ether must possess inertia, that is, it must be able to acquire kinetic energy when set in motion. We might express this in other words by saying that the ether of space must have density, which, though small, must nevertheless be quite fixed and definite. Secondly, as indicated already, the ether must have elasticity, which is the property of obtaining potential energy when a strain is imposed upon it.

We say, quite correctly I believe, that we can only obtain light from a material body of some sort. By material body we mean such things as the heavenly bodies, a candle flame, a red-hot poker, and the like. All these and similar material bodies produce waves in the ether of space.

The transmission of any wave motion through the

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medium which we call ether will inevitably be accompanied by the transmission of energy. Analogy with the transmission of sound waves suggests itself while we are engaged upon the study of the transmission of light waves. I mention this fact quite early in our discussion because it is here that one of Newton's chief arguments against the wave theory arose. Sound, he said, can travel round corners, that is, the waves can bend. If light consists of waves, we should, by analogy, be forced to the conclusion that it would bend round corners. Since the rectilinear propagation of light is a firmly-established experimental fact, it seems difficult to accept the wave theory on these grounds, and it is not difficult to see why Huyghens' wave theory met with such stern opposition from men of letters. It has since been established by work carried out within the last ten or twelve years that sound waves of high frequency, the so-called ultra-sonics, travel in almost straight lines, thus tending to confirm rather than disprove the wave theory of light.

We must now enquire into the method of propagation of these supposed waves. Suppose that light is generated by some material body, as defined above, at the point P. We assume that the ether has similar properties in all directions, and it is then easy to see that the ether waves will spread out in all directions with P as centre. It is just as if one were to throw a stone into a perfectly calm pond. The point where the stone struck the surface represents P in Fig. 3, and the ripples which would be associated with the throwing of a stone into the pond correspond with the waves which we believe to be set up in the ether of space.

Terms Employed

There are a number of terms which are used in connection with the wave theory which must be made clear. We employ the term *wave front* to indicate the plane, perpendicular to the direction of wave tranmissions, to which the disturbance has just reached.

Huyghens held the view that every point along the wave front must be imagined as itself constituting a new centre of disturbance, from which light waves will emerge in all directions. This idea is illustrated in Fig. 3 where the small arcs represent the so-called *secondary wavelets*. A line can be drawn so that it touches each arc, or secondary wavelet, tangentially. This represents the *new* wave front. Thus the new wave is produced as a result of the combined action of the innumerable wavelets which originated at the old wave front. This view as to the mechanism of the transmission of a light wave through space is extremely instructive and interesting. It must be remembered that radio waves are of the same type as light waves, save only in the matter of frequency or wavelength.

Furthermore, we can apply to radio waves many similar arguments such as we apply to light waves, but it should be noted carefully that in some cases the theory may be altered or complicated by the mere fact of this different frequency range, so that it is not always permissible to apply the reasoning of one case to the other.

Zones Theory

As the distance of the wave front from the point of origin of the disturbance becomes greater we shall be able to consider a portion of the wave front as plane. The great difficulty of the wave theory, which was recognised even by Newton, is that while sound, which is a form of wave motion, can bend round corners, the propagation of light is apparently rectilinear.

The idea of zones must also be thoroughly appreciated by the reader, for, although it is not my intention to carry through the laborious details of Huyghens' work, we shall be compelled to speak of these zones. In Fig. 4 let $ABCD$ be a plane, and with O, the centre of disturbance, as centre, describe a sphere of radius $b+\lambda/2$, where b is the distance of the nearest point on the plane to O the circle C_1 will result. All points on this circle are $\lambda/2$ further from O than is the point P. Hence the wavelets must have started $T/2$ seconds earlier than the wavelet from P. There will accordingly be a phase difference between the wavelets from P and C_1 of π radians, or 180°. The space enclosed by the circle C_1 is called the first half-zone period. All successive circles are the result of increasing the radius of the sphere, whose centre is at O, by $\lambda/2$, which is, in effect, a half wavelength of light. Thus the annulus between C_1 and C_2 is the second half-period zone, and so forth. It can be shown mathematically that the first half-period zone is equal to the second, and further, that the area of the third is equal to the first, and so forth. Thus, when the wavelength is small, the area of all zones is equal.

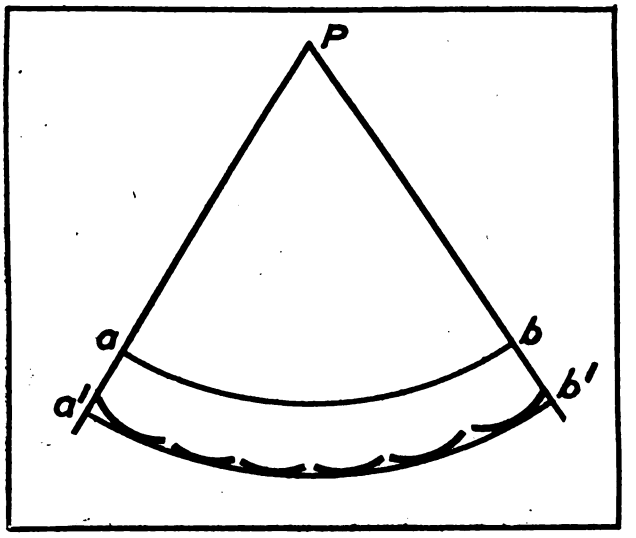

Fig. 3.—The Propagation of Waves.
a b = Old wave front. a' b' = New wave front touching secondary wavelets.

Carrying out further investigations leads us to the discovery that the displacement due to wavelets from any half-period zone is equal, numerically, to half the sum of the displacement due to wavelets from the preceding and succeeding zones.

The importance of the work summarised above will be realised if the reader considers the following. A small body, when placed a short distance from the eye, will often completely obscure a much larger object situated at some considerable distance away.

(*Continued on page 517*)

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The Proceedings of

Meeting, Tuesday, November 5th, 1929

LECTURE ON

"Amplification and Television."

By *F. Langford-Smith*, B.Sc., B.Eng. (Associate Member).

THE November meeting of the Television Society was held at the Engineers' Club, Coventry Street, on November 5th, and in accordance with present practice it was preceded by an informal discussion at which Mr. H. S. Ryland dealt with a number of questions which had been asked as a result of his talk on "Talking Films" at the previous meeting.

The formal meeting was particularly well attended. The chair was taken by Dr. C. Tierney.

* * *

As the outcome of many modern inventions, each of which has enabled some step forward to be made, we now have available to all, such marvels as broadcasting, electric gramophones, talking films, and lastly television. It so happens that all of these are interconnected, since in each case it is necessary to employ an amplifier utilising thermionic valves in order to magnify the minute electrical impulses received to a suitable intensity of light or sound. It is my purpose in this lecture to deal particularly with this one section, but a brief outline of the principles involved in the Baird system of television will prepare the way beforehand.

In television as we understand it a spot of light scans the scene in vertical strips, commencing, say, at the top left-hand corner and moving downwards, beginning successive strips at the top and each slightly further to the right until the whole scene has been covered. This process is repeated from eight to fifteen times per second and so the speed at which the spot of light travels is very great. As the spot of light passes over light or dark parts of the scene, so more or less light is reflected, and this continual change of light is converted into an equivalent change of electrical current. This varying electric current may be broadcast by modulating a carrier wave, and received by an ordinary wireless set giving sufficient amplification and impressed on a neon tube which lights in accordance with the current. Finally, the light from the neon tube is arranged to illuminate the part of the screen corresponding to the position of the scanning light-spot.

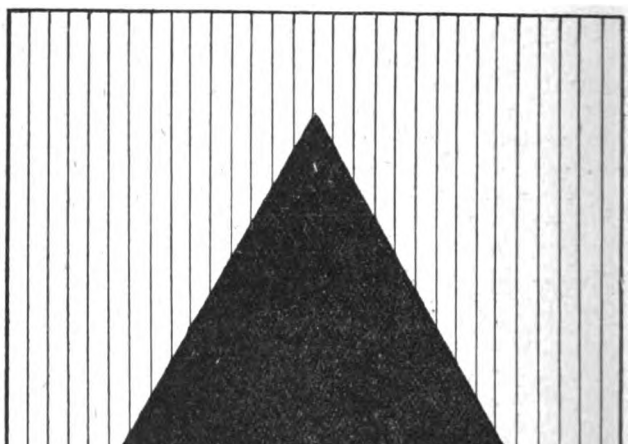

Fig. 1.

The wireless receiver itself may be quite standard, and provided that it is of good design and capable of giving very powerful loud-speaker reception, should give satisfactory results with television. But the conditions for the reception of telephony and television are not identical, and so each section must be considered in detail.

The high frequency amplifier using screen-grid valves is to be very strongly recommended as reaction should not be used owing to the consequent loss of the higher frequencies. One screen-grid stage should never give any trouble, and unless a frame aerial is essential two stages should not be attempted. The

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the Television Society

ABSTRACT OF LECTURE.

Subject—"AMPLIFICATION & TELEVISION."

¶ The general principles of television as used at the present time are briefly outlined, and the requirements of the wireless set for receiving television are determined. The design of a set, and particularly the low-frequency amplifier, is taken step by step, and a suitable design for assumed average conditions is evolved. The required low-frequency amplification is between 1,000 and 10,000 times and the frequency range 300 to 9,000 cycles per second. As thermionic valves are the most important components in an amplifier, their characteristics and the method of calculating them from the curves are explained, and the choice of valves for definite requirements is considered. The alternative methods of coupling valves, namely, transformer, choke and resistance-capacity coupling, are compared with respect to both broadcasting and television, and the correct design of each is fully dealt with.

detector should be anode-bend in order to handle sufficient volume without distortion, and the valve should be of low impedance for a reason to be given later. The tuning circuits should not be too sharp (less so than on an ordinary broadcast receiver) in order to amplify the higher frequencies. Before proceeding to the low frequency amplifier it is necessary to consider the requirements for television.

The L.F. Amplification and Frequency Range

Before designing an amplifier it is necessary to know both the degree of amplification and the frequencies to be amplified. In a broadcast receiving set the low frequency amplification is not usually more than 300 or 400 times, and the frequency range is from 25 to 8,000 cycles per second in the very best sets, but over a much smaller range in the average set. In television receiving sets a very much greater amplification is required and the frequency range is different. Experience shows that an amplification of 10,000 is of the right order, that is to say that the amplification is about twenty times that of the average broadcast receiver. It is advisable to make up some of this amount in the high frequency stage, and it is for this reason that the importance of a good screen-grid valve is stressed. The Mazda 215 S.G. has an amplification factor of 450 with the correct high tension voltage, and the Mazda AC/SG an amplification factor of 1,200. If either of these valves is used the increased amplification should permit a low frequency amplifier giving an amplification of about 1,000 or even less to be used satisfactorily.

We have now to consider the frequency range required, that is to determine the lowest and highest frequencies to be amplified. In scanning the scene there will be a great variety of possible combinations of light and shade, and it is now necessary to decide upon the essential forms. As a simple case consider the black triangle of Fig. 1. If we assume 30 scanning strips, the intensity of light can be represented by the thickness of the lines in Fig. 2. It is obvious that there is a cycle of operations occurring at the frequency with which the whole scene is scanned, say ten times per second as a convenient figure for calculations. The wave-form will be flat-topped somewhat as shown in Fig. 3(*a*). Now it is possible by the application of the Fourier Series to analyse any wave-form and reduce it to a number of sine waves of various frequencies. Of these the fundamental has the same frequency as the original wave, in the present case 300 per second, the next following being the first of a series of harmonics of twice, three times, four times, etc., the fundamental frequency. For a wave of the form shown in Fig. 3(*b*) the equation is

$$e = E_1 \sin wt + \tfrac{1}{3}E_1 \sin 3wt + \tfrac{1}{5}E_1 \sin 5wt + \ldots$$

while the equation for Fig. 3(*a*) brings in the even

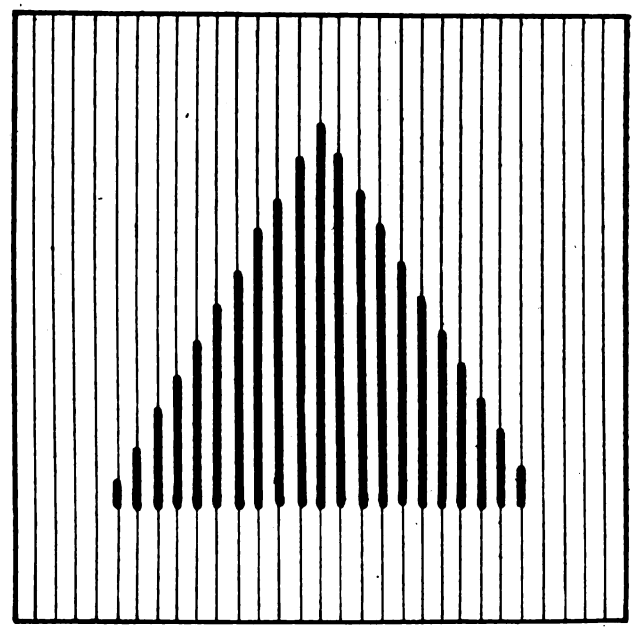

Fig. 2.

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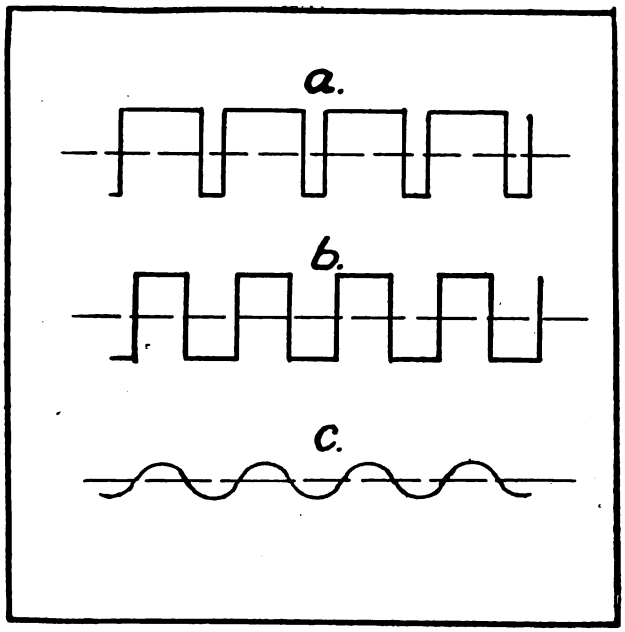

Fig. 3.

harmonics. In both cases the fundamental frequency is the same, namely, that of the sine wave 3*c*. It is obvious that the lowest frequency is this fundamental which is the number of scanning strips multiplied by the views per second, in this case being $30 \times 10 =$ 300 cycles per second. The equation brings in very high harmonics and in order to reproduce correctly a flat-topped wave-form these must be uniformly amplified. But there is great difficulty in amplifying these high frequencies and there is a definite limit, due to broadcasting regulations, at 9,000 cycles. What is the effect of losing those frequencies above 9,000 cycles per second, and what limitations does it impose on television ? An actual series of calculations by the writer has shown that even for the case previously mentioned the cut-off of the higher frequencies would be quite noticeable, while, of course, for more ambitious television the effect is proportionately greater. The visual effect is to round-off and smooth over sharp contours so that small details are lost. It is preferred by some experts to treat the picture as a series of small dots like newspaper illustrations, and to assume that the highest frequency must be greater than the number of dots covered per second. This is not an accurate point of view since usually quite a number of adjacent dots are of the same shade, but if we assume it for the moment as a criterion the required highest frequency is $30 \times 30 \times 10$ $=9{,}000$ or more, while for $100 \times 100 \times 10 = 100{,}000$ cycles per second. The former case is just within the fixed limit, and it looks as though the latter were impossible but fortunately the actual position is not so bad. It is difficult to say how television will develop, but a wider frequency band may be permissible or several transmission channels may be used.

However, the position is now clear for the design of an amplifier. It is necessary to amplify between 1,000 and 10,000 times over a frequency range from 300 to 9,000 cycles per second.

The Amplifier

An amplifier consists of a suitable number of valves coupled together by any suitable means. I intend dealing first with valves in general and then later with the methods of coupling and the choice of suitable valves.

1. Thermionic Valves.

For our purposes we may accept the valve as a component which has certain known characteristics, without being concerned with its internal design. As a typical example of modern valve design take the new Mazda L.210, a two-volt low frequency amplifier or small power valve. From the characteristic curves shown in Fig. 4 it is possible to determine the principal constants of the valve.

There are six variables which must be considered in a complete determination :—

1. Filament voltage.
2. Filament current.
3. Grid voltage.
4. Grid current.
5. Anode voltage.
6. Anode current.

Now provided that an adequate electron emission is attained the filament voltage and current may be settled purely from the convenience of battery supply. If then by the usual convention we regard the negative end of the filament as being earthed the number of variables is reduced to four. Moreover, as an amplifier the valve should be controlled so that the grid current is zero and a further variable is thus deleted.

It is now important to consider the connection between grid volts, anode volts, and anode current.

1. The rate of change of anode volts with grid volts

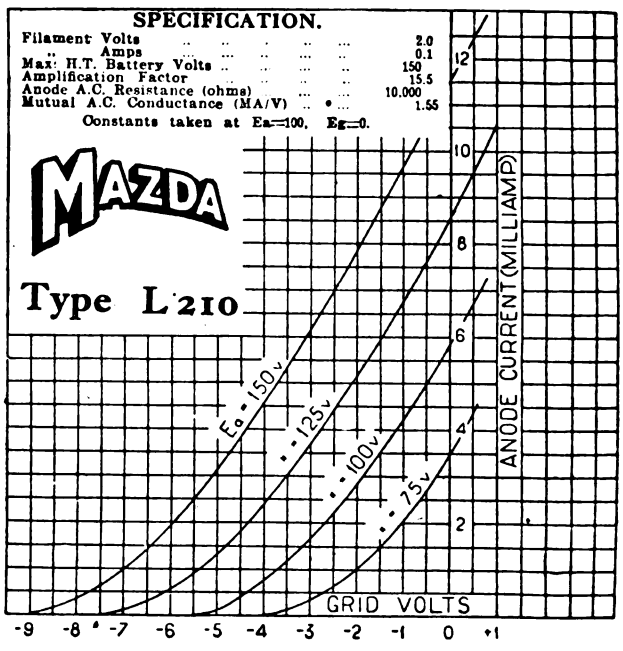

Fig. 4.

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(i.e., the partial differential $\frac{\varrho Ea}{\varrho Eg}$ or the amplification factor).

2. The rate of change of anode current with grid volts (i.e., $\frac{\varrho Ia}{\varrho Eg}$ or the slope).

3. The rate of change of anode current with anode volts (i.e., $\frac{\varrho Ia}{\varrho Ea}$ or the impedance).

It is possible to derive all these values from the characteristic curve of Fig. 4. As a convention they are taken at anode volts 100 and grid volts 0.

The Rate of Change of Anode Volts with Grid Volts.—If the anode voltage is increased by 25 the negative grid voltage necessary to neutralise the change is 1·6. Thus 1·6 volts on the grid are equivalent to 25 volts on the anode, and the amplification factor is 25÷1·6 or 15·5.

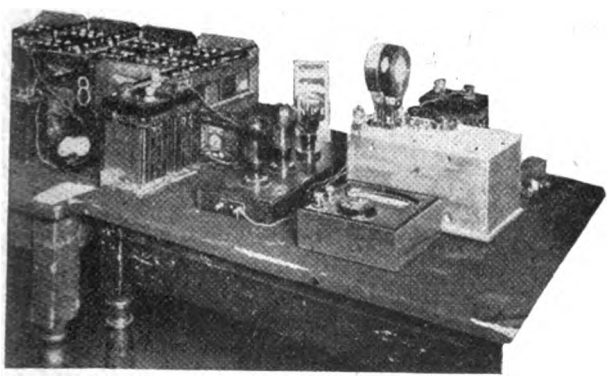
The Rate of Change of Anode Current with Grid Volts.—At anode volts 100 and grid voltages −0·5 and +0·5 the anode current is 5·0 and 6·55 milliamps respectively. Thus the change in anode current for 1 volt grid change is 6·55−5·0=1·55 milliamps, and the slope is 1·55 milliamps per volt.

The Rate of Change of Anode Current with Anode Volts.—When the anode voltage is increased from 100 to 125 the anode current changes by 2·5 milliamps. Thus the impedance is 25÷0·0025 or 10,000 ohms. It should be noted that the valve cannot be treated as a resistance obeying Ohm's law, and the so-called impedance only holds on the straight portion of the curve.

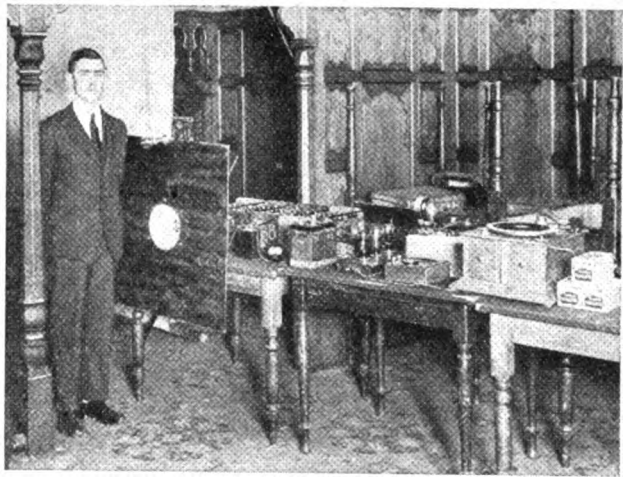
It is obvious that these three functions are interdependent and that when two have been determined the third follows immediately. The real test for the efficiency of a valve is the slope, sometimes called the mutual conductance, which is the ratio of the amplification factor to the impedance, and therefore in the same impedance class the valve with the highest slope is the most efficient. For high impedance valves the slope varies from 0·4 to 0·8, for intermediate values from 0·6 to 1·25, and for low impedances from 1·0 to over 3·5.

2. Methods of Coupling Valves.

There are two principal methods of coupling, transformer and resistance-capacity coupling.



A close-up of the amplifier and batteries.



General view of Mr. Langford-Smith's demonstration apparatus.

One satisfactory means of coupling stages in an amplifier is to use a suitable transformer which at once isolates the grid from the anode voltage of the first valve and also gives a voltage step-up. At the present time the design of transformers has been brought to such a high state of perfection that it is possible to give a sufficiently uniform amplification of about 35 per stage over a frequency range from 25 to 8,000 cycles. This is very satisfactory for the reproduction of music and speech, and the distortion due to two transformer-coupled stages used with suitable valves may be regarded as neglible. Now an inductance such as the primary of a low frequency transformer causes a phase displacement which cannot be detected by the ear, but it can be detected by the eye and transformer or choke coupling will cause visual distortion in television, and should only be employed in cases where the distortion may be neglected.

There are three parts of a transformer to be considered, the primary and secondary windings and the iron core. The requirements for good amplification over a wide frequency range are:—

1. *A Large Inductance Primary.*—This is obtained by having a large number of turns on a large core of good permeability. For broadcast reception an inductance of 50 henries or more is desirable in order to amplify the low frequencies, but for television a much smaller inductance is satisfactory.

2. *A Good Step-up Ratio.*—The greater the step-up ratio the greater the amplification, but a limit is set to the size of the secondary from distributed capacity effects. In good transformers every care is taken to reduce capacity to the minimum, but even with this careful design the size is limited. As the primary is fixed already and the secondary is limited in size, the step-up ratio is fixed, and a value of 3 or 3½ is very usual. Transformers with a larger step-up ratio are usually constructed with a small primary at the expense of the lower frequencies, but for television purposes would be quite satisfactory if the higher frequencies are properly amplied.

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Valves for use with transformer coupling must be carefully chosen for their work. In order to amplify low frequencies down to 50 or 25 cycles, the impedance should be fairly low. For a primary inductance of 50 henries the impedance of the valve should be less than 20,000 ohms, and with lower primary inductances it should be correspondingly less. If as in television it is not necessary to amplify the lower frequencies a valve with a higher impedance could be used, and the consequent higher amplification factor will give a

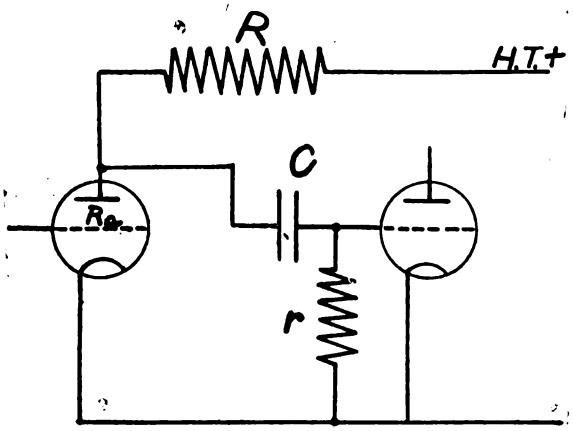

Fig. 5.

greater output. At the same time it must be remembered that there is a limit to stability, and that although a single stage of high amplification transformer coupling is satisfactory, two or three stages will probably prove unstable. If great care is taken three transformer-coupled stages may be used but the following recommendations will ensure stability.

1. Use separate anode-feed resistances and large by-pass condensers.

2. Separate the valves as far as possible and place the transformers in the position found most satisfactory, usually with successive cores at right angles.

3. Completely shield each stage with heavy sheet iron well earthed.

4. Use separate grid bias batteries.

5. Insert a resistance of between 10,000 ohms and 50,000 ohms between the transformer grid terminal and the grid of the valve.

6. Use push-pull amplification for the last stage.

Resistance-Capacity Coupling

The second important method of coupling is known as resistance-capacity coupling, the resistance being used to supply anode current to the valve while offering a fairly high impedance to the output and the condenser isolating the grid of the following valve from the anode voltage while offering a low impedance path to the output. In addition to these a grid leak is necessary to prevent an accumulated charge on the grid.

As the anode resistance R in Fig. 5 shunts the output, it is desirable from this point of view to make it as high as possible. As the coupling condenser C offers an impedance to low frequencies it should be made sufficiently large. Neither of these values are by any means critical but in a case such as the present one where amplification of high frequencies is essential, very careful design is needed.

The most important effect to be considered is the input impedance, that is, the effect of the grid capacity and grid-filament resistance. Normally the grid-filament capacity of an average valve is about 10 micro-microfarads, the internal grid-filament resistance too high to have an appreciable effect, and the grid leak is about 2 megohms. But it is found that when the valve is functioning as an amplifier there is a very important change in this input impedance, depending on the load in the anode circuit. Although the analogy is not strictly true, it can be compared to the increase in the primary current of a transformer as the secondary load is increased. Thus when the secondary load or anode load is zero the primary or grid-filament current is quite small and easily calculated. It is possible to choose constants so that the effective grid-filament capacity is 100 times as great as its measured static value, and for our purposes in designing an amplifier it is essential to reduce this to the minimum. It is possible to calculate to a close approximation the effective grid-filament capacity from the expression—

Effective capacity $= C\,(2+M)$

where C is the measured capacity.

$$M = \frac{R}{R+Ra}\,\mu$$

$=$ actual amplification;

where μ is the amplification factor,
R is the anode resistance,
Ra is the valve impedance.

From this it is seen that if the amplification per stage is 20 the effective capacity is 22 times the measured static capacity, and at high audible frequencies this larger value has considerable effect. Actually the following valve has a very considerable effect, and the capacity calculated above which is correct for a single stage does not hold for two stages, the effective capacity in this case being even greater.

There is also an effective grid-filament resistance due to the anode load, but its calculation is rather difficult and cannot be explained in detail in this lecture.

For the purpose of simplifying the calculations a specific case has been taken and in choosing the constants attention was paid to the requirements for television. Firstly, it is necessary to choose the best valve, and the criteria by which it is to be judged are: (1) The greatest possible amplification factor; (2) the least possible impedance.

Although these appear mutually contradictory, there is on the market a valve which is very close to the ideal, and fortunately for our purpose is quite satisfactory from all points of view The Mazda AC/HL has an amplification factor of 35 and an impedance of 13,500 ohms giving the astonishing

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slope of 2·6 milliamps per volt. An anode resistance of 50,000 ohms gives a static amplification of 29 and yet is not so high as to cause loss of the higher frequencies. Its amazing characteristics are due to its unique construction, being an indirectly-heated kathode valve without any of the faults common to this type such as grid emission, and with inter-electrode capacities no greater than those of the average battery valve. Although primarily intended for use on alternating current mains, it can be used equally successfully with direct current mains or accumulators. In the latter case a very useful feature is that the correct grid bias is easily applied by connecting the positive end of the heater to the kathode and the negative end to the grid leak. Taking the above values as the basis of calculations, the writer has determined both the input impedance and the stage amplification at 9,000 cycles on the assumption that the valve considered is one of a series extending to infinity in either direction. The error due to this assumption is not very large compared with certain other factors such as stray coupling, and the results should not be far from the true position.

Input impedance at 9,000 cycles = 30,000 ohms.
Amplification at 300 cycles = 29
Amplification at 9,000 cycles = 23

It is seen that the amplification at 9,000 cycles is 80 per cent. of that at 300 cycles, so that even with three stages the loss would not be noticeable.

Now to consider the amplification of the whole number of stages. Assuming an amplification of 25 per stage, two stages will give 625 times, and a power valve to follow will increase this to several thousand times. A very suitable power valve is the Mazda AC/P with an impedance 2,650 ohms, amplification factor 10, and slope 3·75. These three valves due to their unique characteristics will give an overall amplification greater than four valves of the ordinary type, and it is for this reason that they have been taken as the basis for calculations, but equally good results can be obtained by using a greater number of stages of the less efficient valves. There is one matter which has not received much attention in this discussion due to its lesser importance in television, but in broadcasting the coupling condenser plays an important part at the lower frequencies and with transients. A glance at the circuit of Fig. 5 will show that the impedance drop in the condenser *C* is wasted, and therefore at lower frequencies where the impedance is considerable the amplification is reduced. For television any capacity above 0·001 microfarad is suitable, but for broadcast reception 0·005 is the minimum which should be used, and 0·02 is rather to be preferred for better handling of transients.

The grid leak should be as low as possible without appreciably lowering the amplification and 100,000 ohms is generally suitable.

In conclusion it may be said that there are no insuperable difficulties in broadcast reception of television up to the limit of the present side-bands. And also within certain limits the present transmissions are excellent and capable of excellent reproduction, but what the future holds in store who can say? Is it to be wider side-bands, or single side-band transmission, or multiple channels? The wisest man will leave these things for the future and concentrate on the perfection of the present, advancing step by step.

Discussion

MR. T. M. C. LANCE said he would have liked the lecture to go very much further, as Mr. Langford-Smith had dealt very well with the side of amplification which they required at home to pick up the B.B.C. transmissions, whereas most amateurs would want to start with their own photo-cells. He disagreed with the lecturer entirely on the frequency characteristics that the amplifier would be required to deal with: 300 to 9,000 cycles had been suggested as the limit within which they would require straight line amplification, but he thought that they would have to go much lower than 300 cycles. Although he had no mathematical data at hand, his experimental results had led him to that conclusion.

Suppose, instead of the triangle, they had to televise a scene composed of white and black as shown. The spot of light scanning such a scene would subject the photo-electric cell to full light for a considerable fraction of the scanning time, then suddenly it would change to darkness.

If they constructed a curve and assumed that the current from the photo-cell was proportional to the light falling on it they would get a nice level line until they came to the point where the dark portion started. Then the current would fall to zero until such time as the scanning beam started on the bright portion again. It seemed to him that in such a case they might have to descend to as low as 30 cycles.

He had, experimentally, tried this particular type of scanning and made up a picture, half black and half white, and tried to scan it, but all he got at the

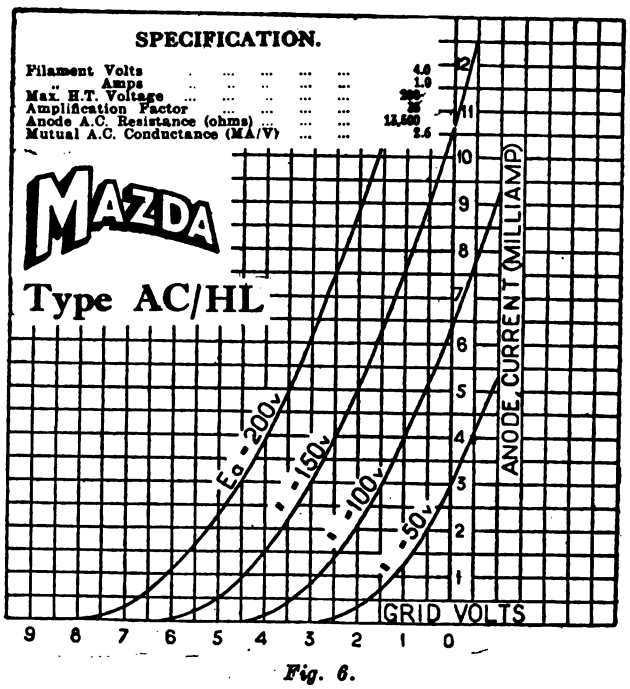

Fig. 6.

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receiving end was a dotted line of light across the middle of a dark field, and he decided that this line of light was due to the fact that the present type of low-frequency amplifier did not respond to direct current input changes. The width of the line corresponded to the "cut off" frequency of his amplifier at about 6,000 cycles.

He felt convinced that in television work they had to go right down to practically zero frequency, or, in other words, they had to have direct current amplifiers, and anyone who had played about with direct current amplifiers knew that they were nightmares, for they amplified everything, from the signals they received to any nearby electrical disturbance.

The present type of multi-valve, low-frequency amplifier did not respond to direct current. If an alternating current was applied to the grid of the first valve it was transferred to the grid of the succeeding valve and so on. But if the first valve was fed from a photo-cell and they shone a steady light on the cell there would only be a kick in the second valve circuit as the light changed, and the subsequent steady current from the photo-cell would produce no effect in the amplifier. When the light was extinguished the current would stop and there would be another little kick which would be amplified, and then nothing would happen until the next beam of light fell on the cell.

The following message from Marquis Marconi was unfortunately received too late for inclusion in our Twenty-first issue :

"Sincere Greetings and best wishes for the success of the Television Magazine.—Marconi."

That was why he had got nothing except a line of light across the screen of his receiver when trying to scan something that was half black and half white.

He suggested that in the ordinary resistance coupled unit they should replace the coupling condenser and grid leak by a battery connected between the anode of one valve and the grid of the next, this battery to be connected with the positive to the grid and the negative to the anode.

Any voltage changes on the anode of the first valve then acted directly on the grid on the second valve and so gave the required results.

A direct current amplifier seemed to be one way out of the difficulty by televising such a scene as he had suggested. There were other ways equally difficult to manage, and one was to make use of an oscillating valve, varying the strength of the oscillating current by the output of the photo-cell, and another was to chop up the light on the cell by passing it through a fast revolving wheel with many holes. Each of the methods would give a carrier current at one high frequency which would have to be rectified at the end of the amplifier to operate the neon tube, but the result would be the same as for a direct current amplifier.

If any of the members wished to do experimental work with shadowgraphs the methods suggested would be worth trying, but for serious television the direct current amplifier was the instrument they seemed to require.

MR. R. POOLE congratulated Mr. Langford-Smith on giving them a thoroughly useful paper.

One of the points emphasised was the width of the side-band required. The present system of broadcast transmission could only use 4·5 kilocycles each side of the actual wave on which the transmissions were sent out. They had just seen that that was not sufficient for good reproduction and detail.

There were several methods of increasing the width. One was to go down to shorter wavelengths with wider side-bands, but that did not help very much, because the amplifier necessary to amplify uniformly was a very difficult proposition to build and, as far as he knew, had never been produced yet.

Another alternative was that of multiple channels, which again was a disadvantage, for it meant taking up the full amount of room in the ether with a multiplicity of channels, and it seemed, as far as this country was concerned, rather an impossible method. Incidentally, the Bell Telephone Company, using seven channels, had been able to run up the telephone carrier frequencies for individual transmission to about 20,000 kilocycles, which enabled them to make use of something like a quarter of a million cycles. The only immediate possibility in this country seemed to be to use a system suppressing one-half of the side-band, and then work over the full limit which present conditions entitled them to use. This would mean that instead of having a range of 9 kilocycles they had a range of 18.

The ordinary limits of speech frequency seemed to be about 4,500 cycles, which, he believed, was the limit to which gramophone makers attempted to

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record. Good electrically recorded gramophone records were remarkably good.

Broadcasting went to a slightly higher frequency, but the reason why it was apparently so good was not because our amplifiers produced the higher frequencies, but because we did not notice the absence of the high frequencies.

Another point he wished to raise was the question of specifying amplification performance in terms of transmission units. This, he thought, would simplify their calculations and give them a more reliable method of arriving at stage gain.

MR. C. H. WESTCOTT said he thought that they were all wrong in considering their amplifiers. They started off with a direct current output from the photo-electric cell and then had to convert it into a suitable frequency. It seemed to him that it would be much better if the direct current was converted immediately into high frequencies. They had had a whole lecture on the trouble of designing low frequency amplifiers and he wanted to get rid of them. If a photo-electric cell gave direct current, surely direct current amplifiers could be perfected if necessary.

With regard to transmitting, he suggested that the output from the photo-electric cell could modulate the transmitting valve direct. He would like to see the intensity of the carrier wave directly proportional to the amount of light falling on the cell.

At the receiving end he would cut out low frequency amplifiers completely and do all the necessary amplification on the high frequency side. If at the transmitting end they made the intensity of the carrier wave directly proportional to the light falling on the cell there would be no need in reception for low frequency amplifiers of any kind.

MR. LANGFORD-SMITH, replying to the discussion, said that with regard to speech frequencies he understood that 95 per cent. of the energy in speech was below 500 cycles. It was a matter of interest that if they blotted out that 95 per cent. and amplified the remaining 5 per cent. correspondingly, the intelligibility of the speech was very little decreased. The ear could so adapt itself to missing everything below 500 cycles that one could hardly tell the difference.

With regard to Mr. Westcott's suggestion that the carrier wave should be made directly proportional to the light falling on the cell in television transmissions, it would mean that the wave-length would range between zero and infinity, and, furthermore, it was impossible to design a high frequency amplifier with a level characteristic for the range he would want.

A vote of thanks to the speaker closed the meeting.

SOCIETY NOTES

HASTINGS.—The Society was represented at Hastings on the occasion of the unveiling of the plaque erected by the Borough Council in honour of Mr Baird, who first conducted his experiments in the building to which it is attached, by Dr. Tierney, Chairman of Council; Mr. Keay, Treasurer; and Mr. Denton, Joint Hon. Secretary.

The President, Sir Ambrose Fleming, F.R.S., notified regret for his absence, and his letter will be seen elsewhere in this issue.

A promising group centre exists in this town, and Mr. Nye (local secretary) with Mr. Sherman (treasurer) had around them local members of the Society.

Members of the Society at Birmingham met at the Chamber of Commerce, Birmingham, on November 13th, for the purpose of forming a local group centre. Mr. Latour Hordle acted as chairman of the meeting, Mr. F. L. Farmer undertaking the duties of secretary (472, Bordesley Green, Birmingham).

Affiliation to the Television Society has been granted by Council to the Scientific Society, Birmingham Midland Institute, and to Newcastle-on-Tyne Radio Society.

The particulars promised regarding lectures in connection with the formation of group centres are as follows:—

December 10th.—The Technical School, Rochdale.

December 11th.—The Technical School, Wigan.

December 12th.—The College of Technology, Manchester.

December 13th.—The University Building, Liverpool.

December 17th.—Hotel Metropole, Leeds.

December 18th.—The University, Sheffield.

December 19th.—Technical College, Derby.

The lectures will be given by Mr. Keay, at 7.30 p.m., and the members' secretary will be in attendance.

Persons desiring to attend any of the above lectures are requested to apply to headquarters for tickets before December 9th.

New members joining now will be interested to know that subscriptions will not again become due until 1931.

The next lecture will be on Tuesday, December 3rd, at 8.0 p.m., when Mr. E. George Lewin, M.Sc., A.Inst.P., will deliver his lecture entitled "Television—Some Suggested Schemes," Mr. Priechenfried, who was originally down for this lecture, having been called abroad on business. We hope that it may only be that Mr. Priechenfried's lecture is postponed for a while.

The lecture secretary wishes to thank all those members who have sent corrections for the printed "List of Members." A copy has now been posted to every member of the Society. Any member who does not receive his copy by December 1st is asked to write to headquarters, when the matter will be investigated.

J. J. DENTON, A.M.I.E.E.,
W. G. W. MITCHELL, B.Sc.
Joint Hon. Secretaries.

Teacher: "Stands Scotland where she did?"

Pupil: "No, Sir; daddy says it's 300 miles nearer, now we've got Television."

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The Origin and Progress of Television

A Statement of Facts

By *Clarence Tierney*, D.Sc.

THE history of television is of comparatively recent date, though, if one may judge from some articles which have appeared in certain recent works of reference, there would appear to be some confusion of thought as to its origin. It is deemed desirable, therefore, to state as concisely as possible a few authenticated facts concerning its history and development, quoting where necessary from published records which are readily accessible and easily verified.

The first demonstration of television in the history of the world was given by J. L. Baird on January 27th, 1926, at Frith Street, London. Prior to this demonstration nothing but the electrical transmission of silhouettes had ever been accomplished.

Now it is astonishing to find how many writers in technical and other journals fail to understand the difference between shadowgraphs and the living image, and a simple illustration will, it is hoped, make this clear. If a person is sitting in a room illuminated by a lighted candle from a table in the centre a shadow of that person will be projected on to the wall. If, now, we place a mirror on that wall we shall observe not a shadow but the living image of that person with all its gradations of light and shade and those delicate inflections of facial expression and movement. Just so with the electrical transmission of shadowgraphs, which is one thing, and the transmission of the living image which we call television. The one is merely a silhouette of the object, while the other, a very different thing, is the real image.

The original apparatus with which Baird first demonstrated his epoch-making discovery is now housed with the national collection of historical instruments in the South Kensington Museum, and the following is the inscription placed upon it by the authorities:

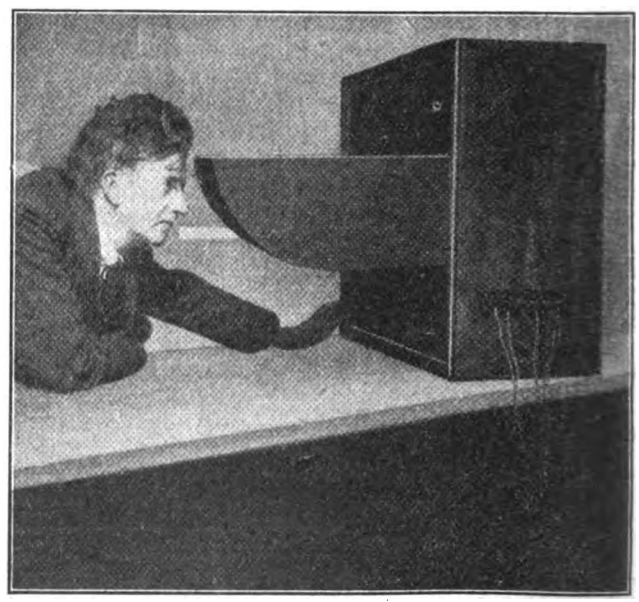
"ORIGINAL TELEVISION APPARATUS
MADE BY
J. L. BAIRD.

"This is the transmitting portion of the original apparatus used by Mr. J. L. Baird, in experiments which led him from the wireless transmission of outlines in 1925 to **the achievement of true television nine months later, when on January 27th, 1926, the transmission of living human faces with light, shade and detail was demonstrated before members of the Royal Institution, this being the first demonstration of true television ever given.**"

It will be observed that this original demonstration was well attested by competent witnesses, and in *The Times* of January 28th, 1926, we read:

"Members of the Royal Institution and other visitors to a laboratory in an upper room in Frith Street, Soho, on Tuesday saw a demonstration of apparatus invented by Mr. J. L. Baird. . . .

"For the purpose of the demonstration the head of a ventriloquist's doll was manipulated as the image to be transmitted, though the human face was also reproduced, first on a receiver in the same room as the transmitter, and then on a portable receiver in



Mr. J. L. Baird looking into one of his early Televisors.

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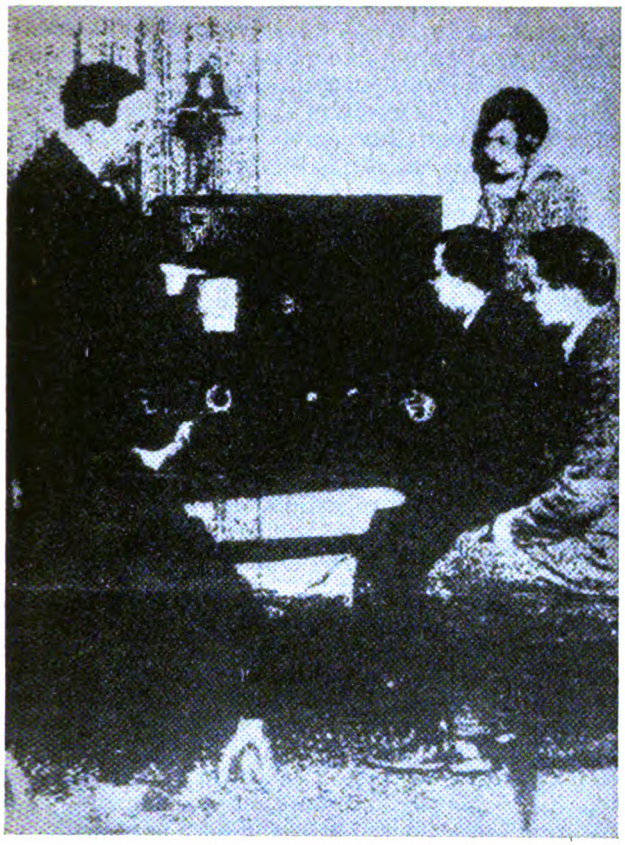


A group looking in to London from Hartsdale, N.Y., on the occasion of Baird's successful Transatlantic transmission of television. This photograph was sent to London by wireless phototelegraphy (NOT *television*).

another room, the visitors were shown recognisable reception of the movements of the dummy head and of a person speaking. The image as transmitted was faint and often blurred, but substantiated a claim that through the 'televisor,' as Mr. Baird has named his apparatus, it is possible to transmit and reproduce instantly the details of movement, and such things as the play of expression on the face."

Another independent witness, Dr. Alexander Russell, F.R.S., Principal of Faraday House, writing a few months later in *Nature*, July 3rd, 1926, says:

"We saw the transmission by television of living human faces, the proper gradation of light and shade, and all movements of the head, of the lips and mouth, and of a cigarette and its smoke were faithfully portrayed on a screen in the theatre, the transmitter being in a room at the top of the building. Naturally, the results are far from perfect. The image cannot be compared with that reproduced by a good kinematograph film. The likeness, however, was unmistakable, and all the motions are reproduced with absolute fidelity. This is the first time we have seen real television, and, so far as we know, Mr. Baird is the first to have accomplished this marvellous feat."

Thus the indisputable fact that Baird was the first to achieve and demonstrate television has been freely acknowledged, and not only in England but also in America, for in the *New York Times* of March 6th, 1927, we read:

"No one but this Scotch minister's son has ever transmitted and received a recognisable image with its gradations of light and shade."

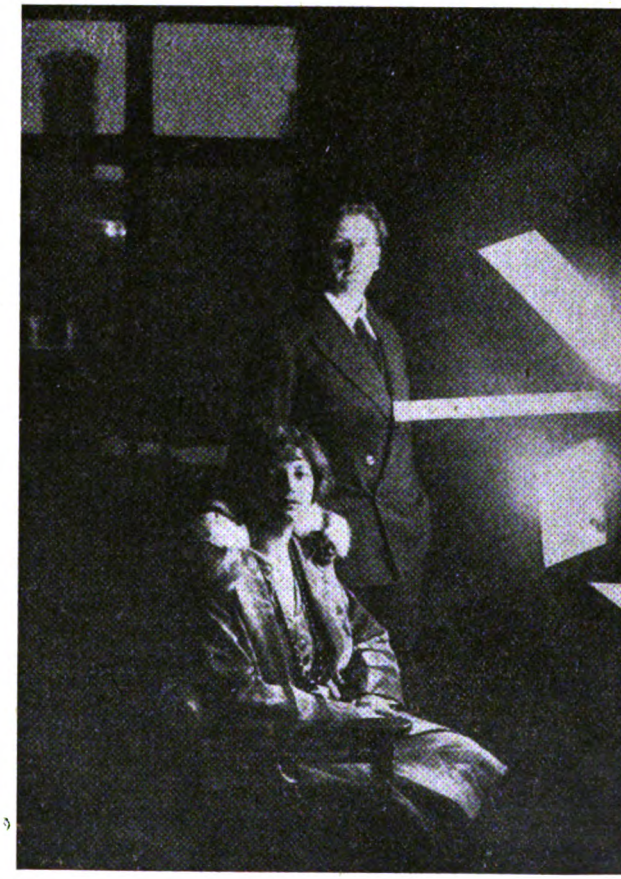
And again in an editorial of the same journal for February 11th, 1928, is the following definite acknowledgment:

"Baird was the first to achieve television."

America's leading wireless journal, the *Radio News*, also paid tribute to Baird's achievement by sending a special commissioner to England in 1926 to witness a demonstration and investigate Baird's claim to priority. This commissioner, reporting upon his visit in the *Radio News* of September, 1926, writes:

"Mr. Baird has definitely and indisputably given a demonstration of real television. It is the first time in history that this has been done in any part of the world."

Much more irreproachable evidence of the same kind could be cited, but it is surely neither desirable nor necessary to labour the matter to establish Baird's claim to priority or the fact that television is fundamentally and in practice a British invention, acknowledgment of which none but an unscrupulous person, whether by design or otherwise, would attempt to suppress.



Miss Dora Selvey photographed with Mr. Baird on the occasion when her image was televised to the "Berengaria" in mid-Atlantic, and recognised on board by her fiancé, Mr. S. W. Brown, the liner's chief wireless operator.

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Let us turn now to some subsequent developments, for it must be remembered that all the demonstrations above referred to had been conducted with only a short separation between the transmitter and receiver, and it was not long before the question was raised as to the possibility of transmitting over great distances.

Baird quickly realised the essential importance of demonstrating that long distances could be covered by these delicate signals between the transmitter and

Transatlantic Transmission:-
SCENE ON "BERENGARIA."

receiver if the system was to be of any practical value in bridging space. Thus he was patiently and unostentatiously pursuing his experiments to ascertain the effects and remedy of extraneous interference when, on February 8th, 1928, he astonished the whole world by **transmitting across the Atlantic from a room in Long Acre, London, to Hartsdale, a suburb of New York (the longest distance ever recorded either before or since)**, the recognisable living image of a well-known New York personality which was immediately identified.

Here again there is no lack of authentic evidence to establish priority in this epoch-making achievement which will for all time remain one of the most outstanding landmarks in the progress of this miracle of modern invention. Thus we read in the *New York Times*, February 11th, 1928:

A Milestone.

"Baird was the first to achieve television at all over any distance. Now he must be credited with having been the first to disembody the human form optically, and electrically flash it piecemeal at incredible speed across the ocean, and then reassemble it for American eyes. His success deserves to rank with Marconi's sending of the letter 's' across the Atlantic—the first intelligible signal ever transmitted from shore to shore in the development of transoceanic radio telegraphy. As a communication Marconi's 's' was negligible; as a milestone in the onward sweep of radio, of epochal importance. And so it is with Baird's first successful effort in transatlantic television."

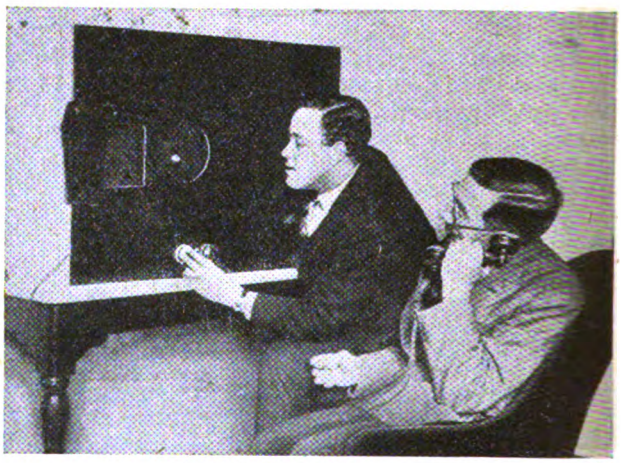
With such an accomplishment to his credit it is not surprising to find **that Baird was the first to transmit an image to an Atlantic liner in mid-ocean** with the same astounding success. A portable receiver was installed on the s.s. *Berengaria*, by means of which when the liner was in mid-Atlantic the ship's officers and others witnessed the reception of the living image of a person sitting before the transmitter in London, who was immediately recognised by Mr. Brown, the ship's wireless operator, as his fiancée. In the *Television* of April, 1928, Mr. Brown writes:

"It was a wonderful experience to be able to see Miss Selvey like that in mid-Atlantic, and the achievement clearly demonstrates the enormous progress which has been made in television."

Longest Wire Transmission.

Previous to these wireless demonstrations, however, Baird had already accomplished **the longest line transmission ever recorded,** *i.e.*, from London to Glasgow. The ordinary trunk telephone line was used, and Professor Taylor Jones, writing in *Nature*, June 18th, 1927, reports:

"The receiving apparatus was set up in a semi-darkened room, the lamp and shutter being enclosed in a case provided with an aperture. The observer looking into the aperture saw at first a vertical band of light in which the luminosity appeared to travel rapidly sideways, disappearing at one side and then reappearing at the other. When any object having 'contrast' was placed in the light at the sending end, the band broke up into light and dark portions forming a number of 'images' of the object. The impression of sideway movement of the light was then almost entirely lost, and the whole of the image



Professor Taylor Jones (right) looking in to London over the telephone line from Glasgow.

appeared to be formed simultaneously. The image was perfectly steady in position, was remarkably free from distortion and showed no signs of the 'streakiness' which was, I believe, in evidence in the earlier experiments.

"The size of the image was small, not more than about 2 inches across when the 'object' was a person's face, and it could be seen by only a few people at a time. The image was sufficiently bright

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to be seen vividly even when the electric light in the room was switched on, and I understand that there is no difficulty in enlarging the image to full size. I was told also that arrangements will soon be made for transmitting larger 'objects,' and for increasing the number of appearances of the image per second.

"The amount of light and shade shown in the image was amply sufficient to secure recognisability of the person being 'televised,' and movements of the face or features were clearly seen. At the second demonstration some of those present had the experience of seeing the image of Mr. Baird transmitted from London while conversing with him (over a separate line) by 'phone.

"My impression after witnessing these demonstrations is that the chief difficulties connected with television have been overcome by Mr. Baird, and that the improvements still to be effected are mainly matters of detail. We shall doubtless all join in wishing Mr. Baird every success in his future experiments."

Thus far I have dealt only with Baird's historical achievements. Next month I hope to review some remarkable developments of the Baird system and its applications, and also give a summary of television experiments in Germany and America.

(To be concluded)

Iceland Broadcasting and Meteorological Station.

The Marconi Company has obtained from the Iceland Government a contract for the first broadcasting station to be erected in Iceland.

This station will be situated at Reykjavic, the capital, and is to be completed in time for the thousand years anniversary of the discovery of the island, which will be celebrated in June next year.

The transmitter will be of a new design, based on the wide experience of the Marconi Company, which has supplied wireless broadcasting stations for service in over twenty countries. It will have a power of 15 kw. in the aerial, and will work on a wavelength of about 1,200 metres.

Special circuits will be incorporated to enable it to be used for telegraphic transmission as well as broadcasting. This will enable the station to be used for meteorological services.

Meteorological information from Iceland is of great importance in forecasting weather conditions for Europe and the Atlantic. The power of the new station which the Marconi Company is building will enable meteorological reports from Iceland to be received over a wide area. It will thus form an important addition to the meteorological services.

CONTRIBUTIONS TO "TELEVISION"

THE Editor invites contributions—interesting articles, sketches and photographs—which will be carefully considered.

While every care will be taken of articles, photographs, drawings, etc., submitted, the Editor and Publishers cannot hold themselves responsible for loss of or damage to such contributions.

The Nature and Properties of Light.

(Concluded from page 505.)

This is because light does not bend round corners in the same manner as sound. We are all accustomed, of course, to hearing a band playing, even though a large building is apparently "in the way."

It is now an easy matter to show, that provided the wavelength of the light is small, which we know to be the case, that this phenomenon of rectilinear propagation is in harmony with the wave theory of light. The phases of wavelets from successive zones differ in phase by π and are therefore in opposite directions. As the order of the zones increases their effects at *O* become more and more nearly equal, so

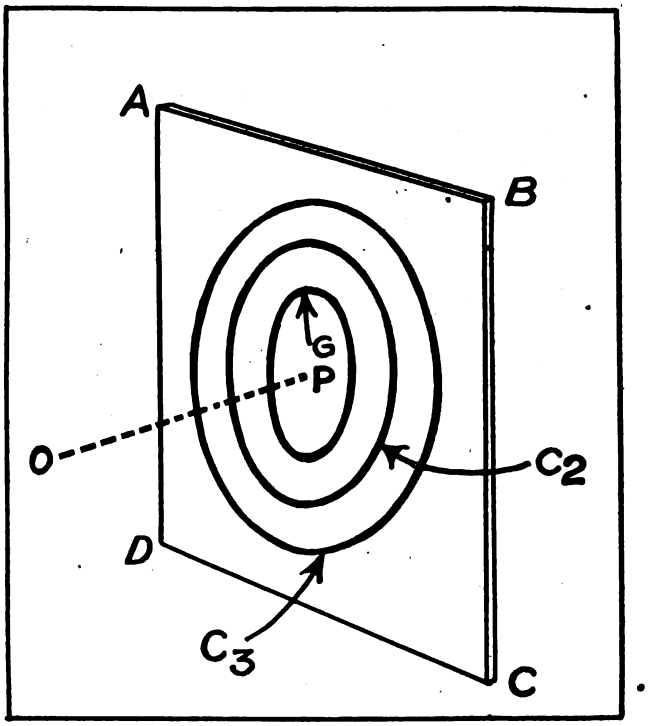

Fig. 4.—Huyghens' Zones.

that the displacement due to one zone of high order is cancelled by the succeeding one. If, therefore, we have an obstacle which will cover the first few zones the wavelets from the remaining zones will just cancel one another, and *no light will be perceived by the eye.*

We can show, moreover, that the screening action at a distance of 100 cm. of an object 2·5 mm. in diameter is complete, and equal, as regards sound, to an obstacle several metres in diameter! The higher the pitch of the note the smaller the diameter of the obstacle necessary to screen off the note, and in the case of ultra-sonics, or high-frequency sound waves, which were employed during the war for locating enemy submarines, almost rectilinear propagation is obtained and the smallest obstacle provides an efficient screen.

Next month we will consider some of the results of the adoption of the wave theory of light, going on later to consider more about vibrations and waves in general. The spectrum, and the knowledge we gain from a study of its properties, will also be discussed in due course.

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The Lower Frequencies in Television

By "*D. C.*"

FROM time to time we read both in the technical and ordinary press of the high frequencies required for television. A hundred thousand has even been suggested quite often, and obviously the finer the detail we aim at transmitting, the higher the frequency we must use, and if we go on increasing indefinitely a point will be reached when to go further would be unnecessary, owing to the eye being unable

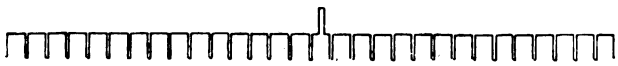

Fig. 1.—The Waveform from a blank screen.

to respond. Of the lowest frequency, however, we hear very little.

Readers who have listened into the experimental transmission by the Baird process being broadcast will be familiar with what might be described as a whistling, chirp-like note, which, if one listens carefully, varies in its tonal character. For the greater part of the time the signal note is fairly similar, but there are periods of a higher and clearer tone which are short in duration compared with the more familiar signal. These shorter periods occur when only a blank screen or background is being transmitted, which means that in the studio they are changing the scene before the transmitter.

Now the higher toned signal from a blank screen will be found to produce a note of about 375 cycles, and is caused by the light spot being cut off for a brief time after every strip, and, as there are 30 strips per picture and 12·5 pictures scanned per second,

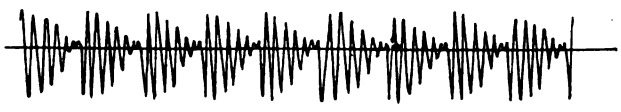

Fig. 3.—Waveform of a continuously sounded "Ah."

we get our 375 note—generally called the strip frequency. This frequency has a rectangular wave form.

In Fig. 1 an attempt is made to draw the wave form from a blank screen whose reflection power, we will assume, is 50, and the extra hump *A* will not be present. In this drawing we are considering the reflected light falling on the photo cells, and therefore the varying direct current flowing in these cells. Obviously, they will not be perfect rectangles, only being drawn as such for clearness.

As has already been pointed out, this frequency is 375, and as this frequency is always present, one is sometimes inclined to think it is the lowest. Unfortunately it is not so, and our amplifiers must pass considerably lower ones or the picture will suffer from heavy black or white shadows or flares, always starting from some given point and going up the picture, often blotting out some of the image. It may be mentioned that a picture suffering from this

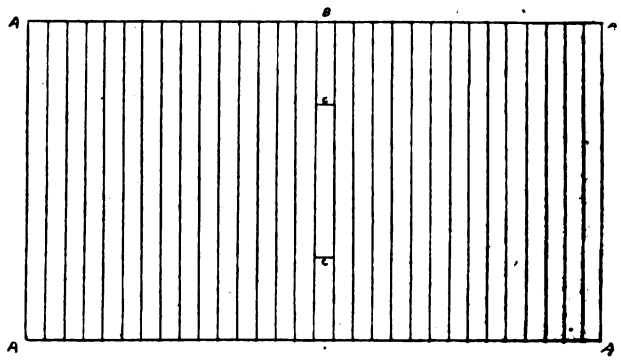

Fig. 2.—A blank screen.

state of affairs can often be improved by applying a weaker signal to the neon, which, though producing a weaker picture, will be more lifelike.

What the lowest frequency may be is dependent on the subject being televised. In Fig. 2, *AAAA* is a blank screen except for part of strip *BB*, of which the portion *CC* has a reflectory value of, say, 100, the rest of the screen having a value of 50. The result of one complete scan will be as shown in Fig. 1, but will now include the hump *A*, and if we are scanning 12·5 pictures per second, this wave form will re-occur 12·5 per second, thus bringing the lowest frequency to a similar number.

Perhaps a similar example from ordinary speech would be of help to make this clear. Fig. 3 is the

(*Continued on page* 520.)

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More Light Through The Scanning Disc

By *George C. Cato*

Associate of the Television Society

ONE of the great difficulties in connection with television is that the amount of light reflected from the object is very small and consequently produces only a very small current in the photo-electric cells. The amount of light may be increased by increasing the size of the holes in the disc, but this reduces the definition of the received image as there is an averaging effect over a larger area. The writer has therefore designed a disc in which an attempt has been made to increase the size of the holes without appreciably decreasing the definition of the image. Before proceeding to an explanation of the principle, however, let us try to obtain a method of representing the definition of an image produced by an ordinary disc with a given sized hole by considering a hypothetical case. We shall then compare this with a similar representation of the definition of the image produced by the writer's disc.

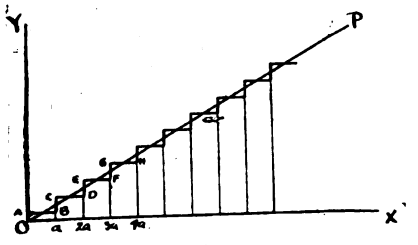

FIG. 1

Suppose we are vertically scanning an object which gradually increases in intensity from left to right; that is, the intensity of light reflected from the extreme left strip is constant over the strip but less than the intensity of light reflected from subsequent strips. The straight line "curve" *OP* of Fig. 1 represents such an object, the intensity being measured along *OY* and the distance from the left edge along *OX*. Now suppose the breadth of the scanning hole be *a*, the intensity of light recorded by the photo-electric cell and reproduced by the receiver will be the average of the intensities over the breadth of the strip from left to right, which is the intensity at $\frac{1}{2}a$, so that the first strip of the received image may be represented by the line *AB* which cuts *OP* at the point corresponding to $\frac{1}{2}a$.

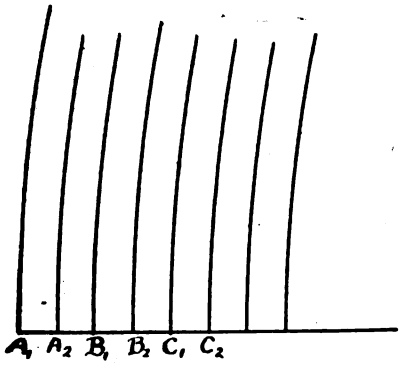

Fig. 3

Intensity Distribution

Similarly the line *CD* cutting *OP* at the point corresponding to $\frac{3}{2}a$ will represent the intensity of the second strip in the received image, and so on for successive strips. Altogether we have the straight line *OP* representing the televised object and the stepped line *ABCDE* . . . representing the received image of the object.

Let us now consider the definition of the image which would result from using a disc like that shown

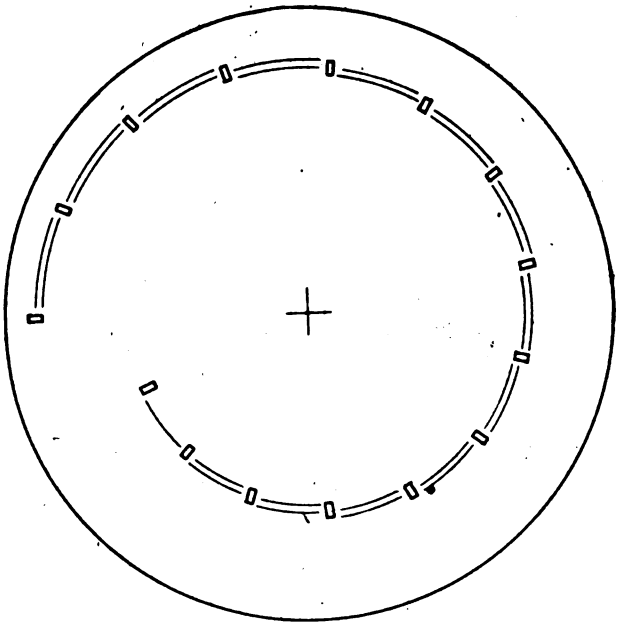

FIG. 2

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in Fig. 2, with holes in which the breadth along the strips is a and the breadth across the strips is increased to $2a$, but in such a way that the paths of successive holes overlap by an amount equal to a. Referring to Fig 3, the outermost hole will scan a strip $A_1 B_1$, the next hole a strip $A_2 B_2$, the third hole a strip $B_1 C_1$, the fourth hole a strip $B_2 C_2$, and so on. In this way the object will in effect be divided up into strips of breadth a as in the case of the ordinary disc, but will be scanned twice for a complete revolution of the disc except for strips of breadth a at each edge, which will be scanned once.

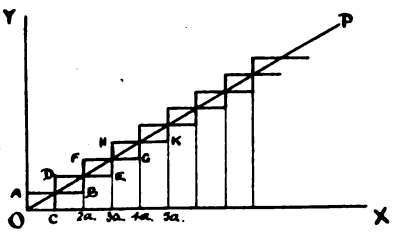

FIG. 4

By the previous argument the line AB in Fig. 4 will represent the intensity of the first strip (i.e., the strip scanned by the first hole) in the received image, DE the intensity of the second strip, FG the intensity of the third strip, and so on. The intensity of the narrow strip $A_2 B_1$ (Fig. 3) will depend on the intensity of $A_1 B_1$ and of $A_2 B_2$. Now $A_1 B_1$ and $A_2 B_2$ are not produced simultaneously but one after the other; the resultant intensity of $A_2 B_1$ will therefore be not the *sum* of the intensities of $A_1 B_1$ and $A_2 B_2$ but their *mean*. That is, the resultant curve of the image is the mean of the stepped curves $ABFG$ . . . and $OCDEHK$ . . . which is exactly the same as the curve $ABCDE$ . . . in Fig. 1.

We have, therefore, according to this argument, doubled the cross breadth of the holes, and kept the cross definition the same. The statement, however, requires qualification in certain cases, e.g., where there is a sharp boundary line between surfaces of different intensity right in the middle of one of the a strips. The change in this case occurs in three steps instead of one, as will be seen by studying the Figs. 5 (a) and 5 (b), but this is a state of affairs which would but rarely occur in practice, and other analyses which the writer has carried out indicate that the result remains substantially true for most subjects which are dealt with at present. The lengthways breadth of the holes has not been altered, so that we may reasonably assume that the definition in this direction remains the same, and since the area of the holes has been doubled we have twice as much light available for affecting the photo-electric cells. It is obvious, of course, that a 30-hole disc in either case will scan practically the same area.

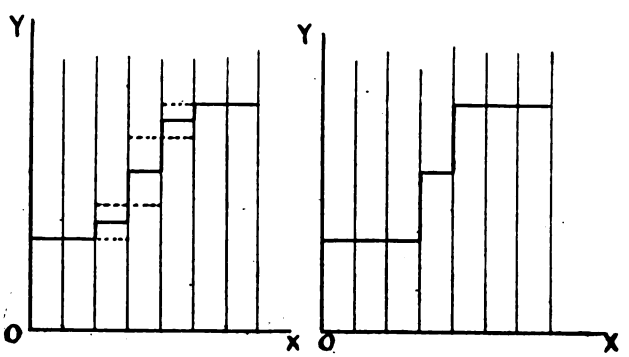

FIG. 5(a) FIG. 5(b)

The dotted lines represent the component intensities.

The writer would emphasise that the above argument is entirely theoretical, and he would be pleased to hear the results of any experiments carried out on these lines.

The Lower Frequencies in Television.

(*Concluded from page* 518.)

wave form of a continuously sounded "Ah." The fundamental frequency was approximately 800, the chief modifications occurring at 120 cycles.

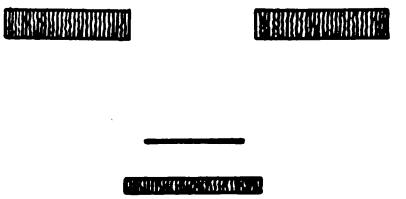

Fig. 4.—"If one televises a piece of paper on which is drawn something like the eyes and mouth of a face, the usual 'face' tone is heard."

As already pointed out, the television note is lower when, say, a human face is being transmitted than a blank screen due to certain lower frequencies than those of the strip being present. By lower tone it is meant that one still hears the strip frequency as a background to the harsh-toned low frequency notes. These lower frequencies are due chiefly to the eyes and mouth. If one televises a piece of paper on which is drawn something like the eyes and mouth of a face, such as in Fig. 4, something like the usual "face" tone is heard.

The strip frequency plays a very important part in the synchronising of our television picture, but in the actual image forming it plays a very small one. The strip frequency is done away with by arranging that as one spot is just passing off the object being televised, the other is passing on: that is to say, although for a very brief period one half only of each spot is on the screen at once, we get just as good a picture.

Practical experience with television apparatus soon shows that it is rather difficult to televise any relatively large areas which are of even tone or reflecting property, owing to the low frequencies which are necessarily involved, and one quickly realises that a direct current amplifier would solve the problem of televising, say, a black background.

In conclusion, the writer would advise any readers who are experimenting in looking-in to use a resistance coupled amplifier, using rather a higher value of coupling condensers than for speech work, say ·1 MF, and anode resistance of a value not higher than that of the impedance of the valve.

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Book Review

A.B.C. of Television, or Seeing by Radio. By R. F. Yates. 205 pages, 78 illustrations. Published by Chapman & Hall. **10s. 6d.**

Any amateur who buys this book, thinking he is getting a work which will tell him something about all television methods at present being experimented with, will be sadly disappointed. He will read little concerning television other than the achievements of the American Bell Telephone Laboratories. In fact, an unduly large portion of the book is nothing but an extensive quotation from the publications of the Bell Telephone Company. While the publications of this vast organisation are justly noted for the very full technical information which they give on the various problems which they have investigated, one scarcely expects them to be used as the main portion of a book entitled "An A.B.C. of Television."

The author, it would seem, is not as acquainted as he might be with the literature of his subject.

He has too thoughtlessly fallen into the error of complaining of the imaginative efforts of the Press, while doing the same thing himself. In his first chapter he states: "Due to the highly imaginative and, at times, flagrantly speculative musings of the Sunday newspaper writers, television is, at the moment, too enthusiastically appraised by the lay public. Already the public is talking of the imminence of home television, perfected to a degree where it will be possible to enjoy a football game or a Presidential inauguration from the vantage point of a luxurious living-room chair."

A few pages further on, and still in the same chapter, he quotes extensively from a skit on the television receiver of the future written by himself and printed in the *New York Herald-Tribune*, which is as "highly imaginative and at times flagrantly speculative" as that of which be complains.

One could, however, forgive him these faults if he had kept to his title a little more closely and not been so blinded by the achievements of one firm, for he is unquestionably all out for the fullest possible development of television.

His first reference to the work of Baird is in these terms:

"The imaginative and at times speculative John L. Baird, whose experiments have caused quite a stir in England, *proposes* a television system operating by the aid of infra-red rays, or 'black light.'"

"Proposes," be it noted, when the system was demonstrated before the British Association at their Leeds Meeting in 1927, and to members of the Royal Institution even before that date. Really, news seems to travel very slowly to America, despite wireless communication.

Sundry other references—and they are very few indeed—to the work of other inventors in this field are equally inaccurate and misleading.

The book bears all the signs of an ill-considered and hasty effort to get into print, and is transparently American from beginning to end. It is, for instance, of little use for an English amateur to read that "tube No. 171," or some other number, is the best "tube" to use for audio amplification purposes, while to be told that a component is mounted "back of" another component, when the obvious word is "behind," is frankly irritating to people used to English. It is also of little use to British readers to give a list of manufacturers of photo-electric cells when nearly all of them are in America and the prices are given in dollars!

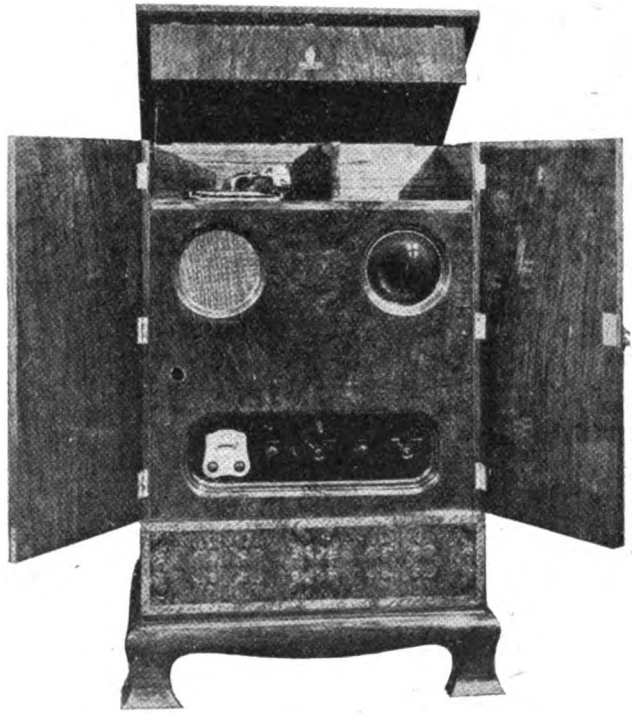
Books written in such a fashion may be quite good enough for the American market and the class of reader that is to be found there, but for other countries it will not do at all.

W. C. F.

BOOK RECEIVED

We have received for favour of review "Practical Television" (2nd edition) by E. T. Larner, published by Ernest Benn, Ltd., price 10s. 6d.

NEW NAME WANTED



The combination of a radio set and a gramophone gave us the name "gramo-radio." The above set, in addition, incorporates television. What shall we call it?

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Television *in* Czecho-Slovakia

An Account of Faerber's Television Demonstrations at the Bodenbach Radio Show

By *Dr. Alfred Gradenwitz*

SUCCESSFUL demonstrations with a home-made television transmitting and receiving set were made at the Radio Show recently held at Bodenbach-on-Elbe (Czecho-Slovakia) by W. Faerber, professor at the local engineering college and one of the early pioneers of the wireless art.

Faerber's apparatus has been designed mainly on the lines adopted, in accordance with Baird's system, by the German Postal Department; it thus comprises Nipkow discs at the transmitting and receiving ends, photo-electric cells, and a glow lamp for reconstructing the pictures, everything being designed according to German standards.

The television transmitter has a 30-hole Nipkow disc, rotating at a rate of 750 r.p.m. The size of the pictures is 3 x 4 centimetres, and the number of picture elements 1,200.

Inasmuch as a simple synchronous motor (La Cour wheel) is hardly suitable for driving large discs like this, small alternating current motors are used both at the transmitting and receiving stations, and are kept in synchronism by the following method.

A small copper disc has been mounted upon the right-hand end of the motor shaft (Fig. 1) which, close to its periphery, carries eight short iron screws. An electro-magnet, fed from the alternating current system across a transformer, acts upon the heads of these screws and, as seen from Fig. 1, has been fitted to the motor socket. The eight poles with a 50-cycle current in the mains will yield a synchronous speed of 12·5 revolutions per second. A glow lamp (3), which is likewise connected up to the mains and which illuminates the disc, enables synchronism, i.e., the perfect agreement in rotation between the discs at the transmitting and receiving ends, to be checked according to what is termed the stroboscopic method. In fact, the number of revolutions under normal conditions in the mains is kept so constant by the synchronising disc that the eight poles seem absolutely immobile in the light of the glow lamp. In order, however, to make up for any occasional slight fluctuations in the number of cycles of the mains, there has been provided an additional regulations by means of eddy currents, as produced by a permanent magnet adjusted by means of a micrometer screw and an aluminium disc. However, as shown by experiments so far made, this additional regulation is only required in exceptional cases.

The easily exchangeable synchronising disc affords the advantage of enabling the same motor to be readily synchronised for widely different numbers of revolutions, by fitting other discs and pole systems, thus using it in connection with tests with various scanning speeds.

A highly efficient Pressler cell is used as the photo-electric cell and has given excellent results in permanent operation.

In order to reduce the capacitive sensitiveness of the conductor connecting the cathode of the photo-electric cell to the amplifier, this conductor has been

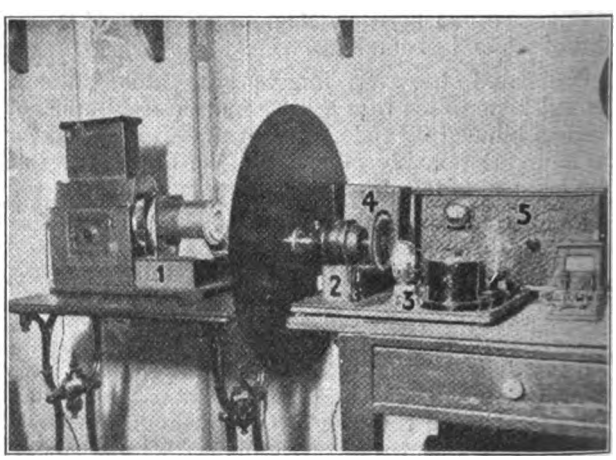

Fig. 1.—Faerber's Transmitter.

1. *Projector.*
2. *Scanning device, Nipkow disc and synchronising disc.*
3. *Glow lamp for checking synchronism.*
4. *Photo-electric cell in light-tight box.*
5. *Amplifier of photo-electric currents.*

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inserted in a short metal tube, which in turn serves as the return lead, connecting with the anode of the cell. This is how a perfect electrostatic protection has been insured.

The amplifier, which is made up of six valves, has been connected up as a resistance capacity coupled amplifier, the terminal valve supplying 40-50 mA current. The first stage behind the cell comprises the milliammeter visible close to the amplifier, which is used in adjusting the grid tension while the photo-electric cell is not under load.

Faerber's receiver comprises a neon-helium glow lamp, with plate-shaped electrodes. This gives best results with a bias of about 200 volts, as derived without any disturbance from a batteryless set and good filter chain.

Modulation is most satisfactory with a choke-condenser arrangement fitted into the receiver box. A switch at the modulator enables positive or negative images to be obtained at will, which possibility is made use of, i.e., in rendering portrait negatives visible immediately as positive television pictures.

Synchronism of the transmitting and receiving apparatus has, throughout the duration of the show, been obtained without any hitch. After once synchronising and adjusting the phase difference, practically motionless pictures were obtained.

Transmissions at the Exhibition comprised the televising of small and medium-sized objects of all kinds, also movable objects held before the transmitter. Lantern slides as well as negatives were likewise transmitted, portraits being rendered particularly well, with even the most delicate shadings.

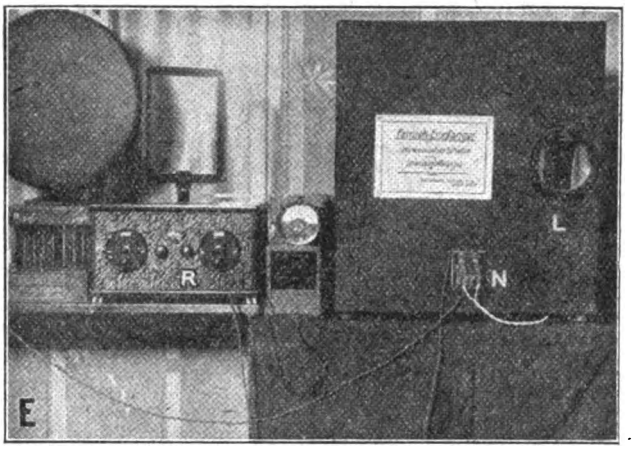

Fig. 2.—Faerber's Receiver.

L. *Observing lens; behind it is fitted the Nipkow disc and neon lamp.*
N. *Switch for changing from loud-speaker to Television Reception.*
R. *6-valve Ultradyne Receiver.*

Transmission over a wire line was adopted at the Exhibition, thus eliminating any disturbance of the wireless reception by other apparatus.

The television receiver is shown in Fig. 2 connected up to an ultradyne set which is now used by Mr. Faerber in "looking-in" at the daily experimental transmissions from Berlin-Witzleben. Another lens has been provided which is so arranged as to insure horizontally lined images.

LETTERS TO THE EDITOR

To the Editor of TELEVISION.

DEAR SIR,—In reference to what is apparently a review of "Wireless Pictures and Television" in the November issue of TELEVISION, I feel that it is only fair to point out that this book was written nearly three years ago. The remark made by your contributor, W. C. F., that "the systems in common use are scarcely mentioned, and in this respect therefore the book is disappointing," while it would be perfectly just criticism had the book only recently made its appearance, can hardly be applied to a book written, and indeed printed, when the "systems in common use" did not exist!

I should feel greatly indebted to your courtesy if you would give publication to this letter.

Yours faithfully,
T. THORNE BAKER.

The Hut,
Hatch End, Middlesex.
November 12th, 1929.

To the Editor of TELEVISION.

DEAR SIR,—As a recent reader of TELEVISION (of which I had no knowledge until a few months ago) I should like to congratulate you on the occasion of the twenty-first birthday of this valuable paper.

I was what Captain Eckersley would doubtless describe as a member of the "real public" up to a few months ago, before starting to read TELEVISION. Then, I suppose, I became utterly degraded. In fact, I was undecided as to whether or not to give you a false name and address in case I brought down upon myself the austere wrath of Captain Eckersley.

But, as I will repeat, having been a member of the "real public"—that is, a person who did not know what television really is, and did not know the wonderful entertainment possibilities it offered, owing to reading what men like Captain Eckersley wrote about it—I think that I am fully privileged to say that Captain Eckersley's views and criticisms are all *wrong*. And this is what the "real public" would think if they only knew, for I find that whoever I explain television to is vastly interested.

Looking forward to your next issue,
I am, yours sincerely,
HENRY MILLER.

190, Rock Avenue,
Gillingham, Kent.
November 12th, 1929.

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INVENTION *and* DEVELOPMENT

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. each.

Patent No. 318331, granted to C. E. C. Roberts: CATHODE-RAY TRANSMITTER.—An optical image of the object being transmitted is projected by a lens *L* (Fig. 1) on to the photo-electric surface of a cathode *K*. The density of electrons in the elementary pencils forming the cathode stream *E* varies according to the

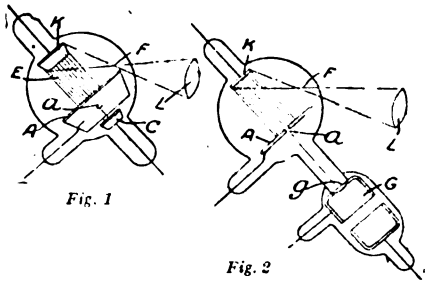

Fig. 1

Fig. 2

intensity of illumination of the surface-elements from which the pencils originate. The anode *A* of the tube is supplied with a small aperture *a*, which constitutes the scanning aperture for the picture as the stream of electrons *E* is made to oscillate in two dimensions (either by electro-magnetic or electrostatic means), thus allowing the elementary pencils to pass

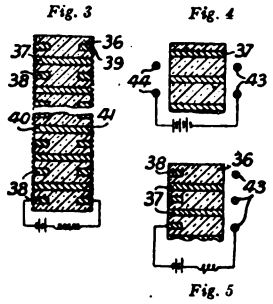

Fig. 3 Fig. 4

Fig. 5

successively through the small aperture *a*. The emerging pencil then falls upon an electrode *C* which is connected to the grid of a thermionic valve or other means for controlling the outgoing signals. Another arrangement (Fig. 2) allows the pencil of electrons emerging from the aperture *a* to pass through an aluminium or other window *g* into an ionisation chamber *G*.

According to the Provisional Specification the cathode stream from the picture may be encased in a more powerful stream which serves to generate synchronising signals.

Patent No. 318299, granted to J. E. Pollack: NEW FORM OF PHOTO-ELECTRIC CELL.—A slab of insulating material 36 (Fig. 3) has conductors 37 which extend right through the slab from face to face and in addition other conductors 38, 39 extending from opposite faces only a part of the way into the slab. These latter conductors form two grids connected in a battery circuit as shown. One face of the slab is coated with material 41, such as selenium or potassium hydride, responsive to cathode-rays; the other face is coated with light-sensitive material 40, such as selenium. The image of the object is formed on this latter coating, which is not thicker than the depth of effective penetration by light, while the other face is scanned by cathode-rays which thus activate the coating and complete the battery circuit allowing currents to flow dependent upon the resistance of the elemental area of selenium on the other face of the slab.

The slab may be of glass, the conductors being fine wires traversing the thickness of the slab, and the grids may consist of fine mesh screens 43, 44 (Fig. 4) adjacent to the faces, or one grid 38 (Fig. 5) may be embedded in the slab and the other grid arranged to be adjacent to the slab.

The Patent Specification describes the detailed construction of the various types of slabs.

The practical applications of the cells described above are detailed in *Patent No.* 318565, also granted to J. E. Pollack. Fig. 6 shows one arrangement of cathode-ray tube 4 (transmitter) with photo-electric plate cell 3 as already described. The resistance of the selenium coating on the front or image side varies with the intensity and colour of the light falling on it, and the circuit from the battery 15 is completed across the inner face by the exploring cathode beam, rendering small areas of the coating 41 conductive, as already explained.

The end of the receiving cathode-tube 22 is a fluorescent screen or a photographic plate 23.

Synchronisation is secured by applying two frequencies from the same generators 13, 14, to the pairs of electrostatic deflecting plates 11, 12 and 28, 29.

COLOUR TELEVISION (Fig. 7).—Three separate images in red, yellow and blue are produced respectively by three-colour screens 52, 53, 54, and projected on the photo-electric plates of three separate cathode-ray tubes *A*, *B*, and *C*, the deflecting plates of which are connected to one common pair of generators 13, 14. The images are transmitted simultaneously to three corresponding cathode-ray tubes *D*, *E*, and *F* supplied with scanning frequencies from the same generators 13, 14, and provided with fluorescent screens of such materials that each screen presents its appropriate

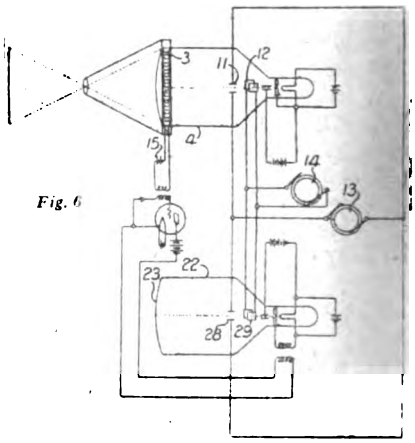

Fig. 6

colour. For example, screen 55 may be coated with bismuth sulphate, 1 part to calcium oxide 100 parts, giving red; screen 56 with antimony oxide 1 part to calcium oxide 100 parts, giving yellow; and screen 57 with bismuth oxide, 1 part to calcium oxide 100 parts, giving blue.

The three images are combined on a screen *H* by cameras *d*, *e*, *f*, and mirrors 58, 59.

For transmission and reception by wireless, energy of four different frequencies is radiated, namely, the modulating frequencies controlled by the photo-electric plate cell, the high- and low-scanning frequencies, and a high frequency carrier wave.

Details of the circuits for transmitting and receiving are shown in the Patent Specification.

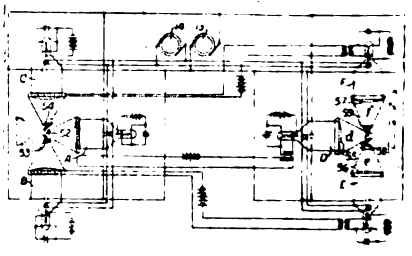
Fig. 7

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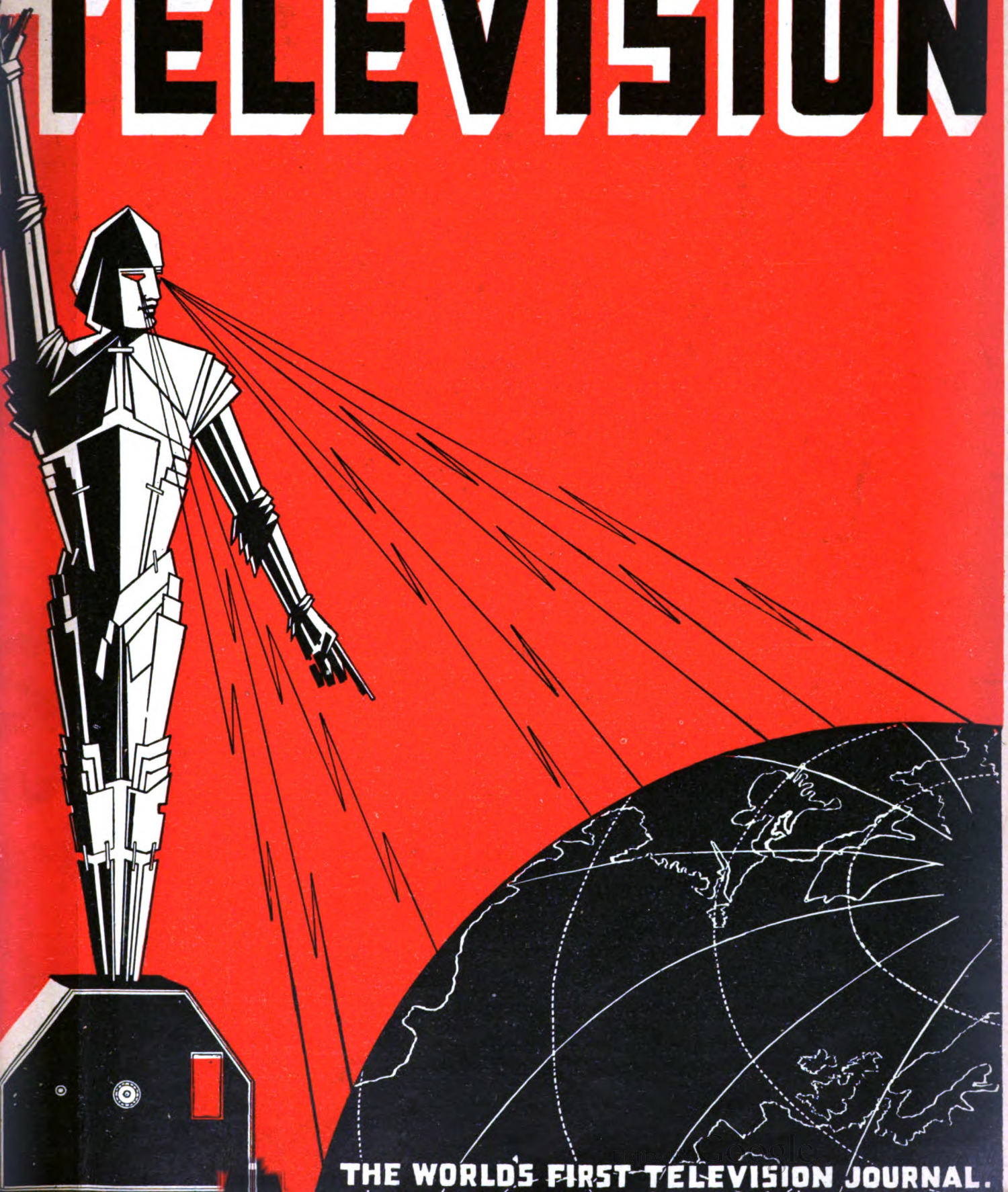

THE WORLD'S FIRST TELEVISION JOURNAL.

THE TELEVISION SOCIETY

The Television Society was founded on September 7th, 1927.

The Society makes its appeal to those who desire to share in the responsibility of furthering this new branch of applied science.

THE OBJECTS OF THE SOCIETY

may be summarised as follows:

(*a*) The Study of Television and its application in applied science and industry.

(*b*) To afford a common meeting ground for professional and other workers interested in current research relating to Television and allied subjects and to afford facilities for the publication of reports and matters of interest to Members.

(*c*) To encourage the formation of *Local Centres* of the Society in the Provinces, so that by social intercourse and discussion among members these aims may be more fully realised.

The present register indicates a world-wide membership.

ORGANISATION

The Society consists of one Honorary Fellow, Fellows and Associates, and the management is vested in a Council of Fellows, including the President, three Vice-Presidents, and Ordinary Fellows.

FELLOWS.—Ordinary Fellows must be elected by the Council. Candidates for the Fellowship must be proposed by two Ordinary Fellows, the first proposer certifying his personal knowledge of the candidate.

ASSOCIATES.—Any person over 21 interested in Television may be eligible for the Associateship without technical qualifications, but must give some evidence of interest in the subject as shall satisfy the Committee.

STUDENT MEMBERS.—The Council have arranged for the entrance of persons under the age of 21 as Student Members.

SUBSCRIPTIONS.—The annual subscription for Ordinary Fellows is 20s., with an entrance fee of 10s. 6d.; and for Associates 10s., with an entrance fee of 5s.

The annual subscription for Student Members is 5s., entrance fee 2s. 6d.

LIFE MEMBERS.—Life Membership may be secured at a fee of £10 10s.

MEETINGS.—The ordinary meetings of the Society are held in London at the Engineers' Club, Coventry Street, W.1, at 8 p.m., on the first Tuesday of the month (October to May inclusive). Notices of meetings are posted to all members about seven days before the meeting

Full-size reproduction of the new Television Society Badge, which is available to accredited Members, and may be obtained from the Head Office, price 1s.

The official organ of the Society is "Television," published monthly by the Television Press, Ltd., 26, Charing Cross Road, W.C.2.

A memorandum for the guidance of members wishing to form a Local Centre of the Society may be obtained (gratis) on application to the Joint Hon Secretaries, 4, Duke Street, Adelphi, W.C. 2.

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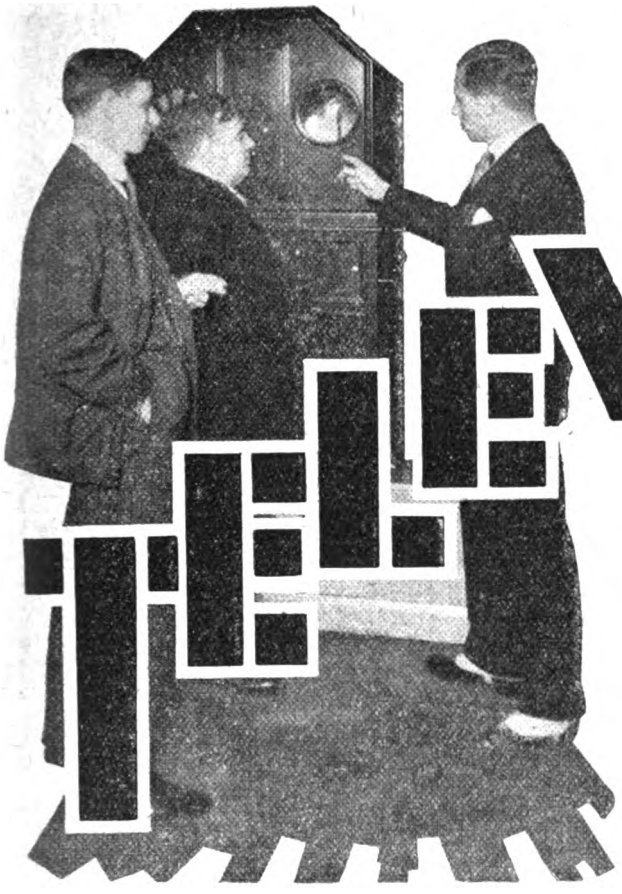

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VOL. II] JANUARY 1930 [No. 23

EDITORIAL

THE last few weeks have been characterised by more Press references on the subject of television than perhaps any period since the birth of the invention. This is largely accounted for by the announcement that although the Baird Television Development Company do not intend to manufacture and market "televisors" themselves they propose, in order to bridge the interim period until manufacturers can get into production, to manufacture and market through the usual channels an initial batch of one thousand instruments. These are expected to be ready for delivery some time during the month of January. This is indeed good news.

Another factor is the recent announcement that extended broadcasting facilities have been granted to the Baird Company by the B.B.C. As we ourselves have pointed out, five half hours a week, between eleven and eleven-thirty in the morning, with no transmissions on Saturdays and Sundays, did not give the amateur much opportunity to make experiments. This has now been fully realised, and the extended facilities which have just been announced refer to two additional half-hour periods at night, after broadcasting hours. The precise days and times have not, at this writing, been announced.

Another recent item of news is the announcement that, now that the second regional station at Brookman's Park has been opened, it will also be placed at the disposal of the Baird Company for the transmission of the sound portion of their programmes. This will enable the accompanying music, singing and speech to be broadcast in addition to television, and permit those members of the public who are equipped with two wireless receivers (one to supply a loud-speaker and one to supply the "televisor") to judge to the full the potentialities of television as an adjunct to sound broadcasting. To be able to see and not hear is just as unsatisfying as to be able to hear and not see. The prospect of this dual service being instituted before the end of January provides a bright prospect of rapid progress in 1930.

In addition to these factors there is also the news that arrangements have been completed for the broadcasting of television through the Dublin station, 2RN. This is good news for those of our readers who are so situated that they cannot easily pick up Brookman's Park, but have no difficulty in receiving 2RN.

Most of the Press comments, to which we referred above, whilst guarded, have been in a strikingly optimistic strain. There are exceptions, of course, and TELEVISION, in its independent capacity, is able to determine whether or not they are worthy of note. If all were agreed that the present system of transmission and

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reception of television were perfect then, surely, the purpose of our existence would fail, and the progress of the invention be brought to a standstill.

We will not, therefore, concern ourselves with those laudatory reports which daily become more common. But we are bound to take notice of an article which appears in the current number of one of our wireless contemporaries. This article, written, perhaps, with the best of intentions, if in haste, describes the efforts which the author has made to receive the television broadcasts which are being sent out daily through 2LO. This author is very well versed indeed in wireless matters, and it might be assumed that such a one would be suitably equipped to make investigations in the field of television, new though that field is. It might also be assumed that, having conducted his experiments and met with strangely provoking setbacks, he would be very careful indeed what he put into writing.

But no; his *amour propre* is so deeply wounded that he must needs launch forth in a tirade against the Baird system saying, in effect: "*I* can't make it work; therefore the system is impracticable." This in spite of the fact that the practicability of the system has been recognised by scientists whose reputation and experience make them competent to judge. But the well-considered judgment of the scientist does not appear to weigh with the author of the article in question. It might almost be suggested that what sets out to be a display of knowledge resolves itself merely into an exhibition of ignorance. Readers of TELEVISION who happen to see the article will recognise immediately the reasons for the author's failure to secure the desired results.

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The Cathode Ray again.

During the early months of 1929 several of our issues contained articles dealing with the use of the cathode ray for television purposes. A paper was also read before the Television Society on the subject, so that our readers are well versed on the state of development to which this utopian idea had arrived up to that time.

From America, however, there has just come the news that Dr. Zworykin, of the Westinghouse Electric & Manufacturing Company, has perfected a practical form of television receiver which makes use of a specially developed cathode ray tube which projects the received image on to a screen measuring four by five inches, thus doing away with the conventional scanning disc and neon tube, and, in fact, with all mechanical parts.

The use of the cathode ray tube was suggested by Campbell Swinton about twenty years ago, and efforts to use it have been made by Rosing, Belin, and several others. Dr. Zworykin's recent development was first referred to by Mr. W. G. W. Mitchell (Joint Hon. Sec. of the Television Society) in the February, 1929, issue of TELEVISION, in an article in which he drew attention to the practical difficulties which lay in the path of investigators who followed up this particular line of research.

However, unlike many of our critics, we are not disposed to be prejudiced; our mission is to champion the development of television as a science, and not by any particular method, and we shall be among the first to welcome any departure from existing practice which will make for progress. Up to the time of going to press we are not in possession of any details of Dr. Zworykin's latest apparatus, but we hope to be in a position to publish these details at an early date.

The Stenode Radiostat.

We have frequently urged in these pages that the real problem of the future development of television does not lie with television engineers, but with wireless engineers; it is up to them to devise ways and means whereby the already overcrowded ether can be made to accommodate television. The solution to the problem would appear to have been found by our well-known contributor, Dr. James Robinson, late Chief of Wireless Research of the Air Ministry. Dr. Robinson has christened his invention the "Stenode Radiostat," and has demonstrated that it has most extraordinary powers of selectivity. We had hoped to be able to include in this issue an article by the inventor himself, describing the technical aspects of his discovery, but unfortunately it has not been possible to do so. At the earliest possible moment, however, we shall see to it that our readers are given the fullest possible description.

"New Name Wanted."

On page 521 of our December, 1929, issue we published a photograph of a combination gramophone-television-radio set and asked: "What shall we call it?" Quite a number of readers have sent in their suggestions for a single comprehensive word which would, in itself, adequately describe the instrument. The best suggestion received so far is *Gravideorad*, denoting gramophone (*gra*) television (*video*, I see), and radio (*rad*). Can anyone beat this?

Happy New Year.

In conclusion, may we most heartily wish you all a happy and prosperous New Year, and if any New Year resolutions are being made, let one of them be: "LET'S MAKE 1930 A TELEVISION YEAR!"

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The Polarisation of Electromagnetic Waves

By *R. L. Smith-Rose*, D.Sc., Ph.D., A.M.I.E.E.

IT is over half a century ago since James Clerk Maxwell gave to the world his mathematical conception of the electromagnetic theory of light waves. His theoretical prediction was that such waves arise from alternations of electric stress in the ether, as a result of which a wave motion comprising electric and magnetic forces is set up and travels in straight lines through space with a definite velocity. In the development of optical physics it was soon evident that ordinary light comprises such electromagnetic waves, the length of which was a very small fraction of a millimetre.

What is termed the colour associated with the light waves was identified as an accompaniment of the wavelength involved, the shortest visible rays being in the violet end and the longest in the red end of the spectrum. Somewhat longer invisible waves were also obtainable, the effects of which could be demonstrated only by their heating properties. With the advent of Hertz's classical experiments, which formed the basis of modern radio communication, a much longer type of wave was discovered, the wavelengths being of the order of a few metres.

The Short Wave Era

In all respects, other than wavelength, Hertz demonstrated in his classical experiments that these waves possessed properties identical with those already familiarly associated with light. While these waves were both invisible and difficult to detect by means of their heating effect, they could be investigated by means of the electrical effects which they produced. After the possibility of using these waves for practical communication purposes had been demonstrated by Marconi, the development of radio signalling over various distances progressed very rapidly. For this purpose it was found at that time to be most convenient to use much longer waves than those employed by Hertz, and the wavelengths in practical commercial use up to a few years ago ranged from 600 to 20,000 metres. At these long wavelengths it was not easy to demonstrate the ordinary optical properties of the waves, and many engineers and investigators have been inclined to overlook the analogy which has always existed between "wireless" waves and visible light.

The advent of the use of short waves, and particularly the ultra-short waves of wavelengths below 10 metres, has given a considerably renewed interest to this matter, for it is now possible to use reflectors of normal dimensions to concentrate wireless waves into a beam, an achievement which immediately brings home the identity of the waves with those of ordinary light.

The introduction of television into the field of radio communication has given a much greater interest in the study of light and optics to investigators in the wireless field, for here both the very short light waves and the moderately long wireless waves are employed in the same apparatus to achieve the projection of images of living scenes to a distant point. Indeed, the television transmitter may be regarded as merely a device for changing the wavelength from that of the visible spectrum to that of the radio range, while the television receiver accomplishes the inverse process after the visible image has been carried through space over the wireless link.

In view of this close connection between the two types of waves it will be interesting to deal in this article with one of the optical properties of wireless waves, viz., "polarisation," and to illustrate the part which this property plays in the propagation of wireless waves over the earth's surface by a description of some experiments carried out by the writer a few years ago.

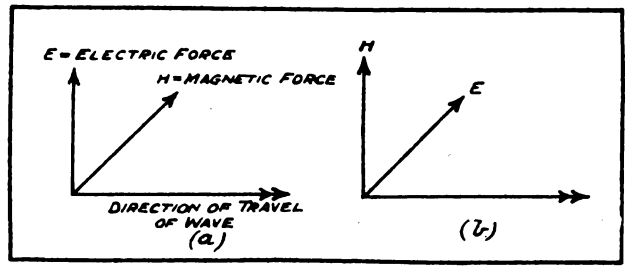

Fig. 1.—Directions of the electric and magnetic fields in relation to the direction of propagation in (a) *a vertically polarised wave;* (b) *a horizontally polarised wave.*

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The term " polarised " originated in the study of optics and its extension to wireless, although perfectly correct, is in some ways unfortunate, since most electrical engineers associate the term with a magnet or an instrument employing a magnet, such as a polarised relay.

Planes of Polarisation in Electromagnetic Waves

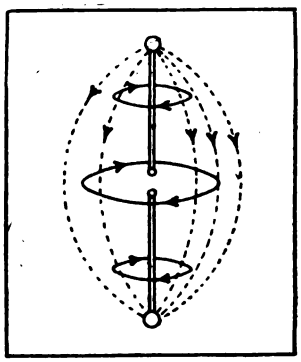

Fig. 2.—Directions of the electric and magnetic fields surrounding a simple Hertzian oscillator.

An electromagnetic wave, whether its wavelength be in the optical or the wireless region, is said to be polarised when the directions of the oscillatory forces in the wave are confined to definite planes. If, for example, the electric force is confined to a vertical plane the wave is said to be vertically polarised.* Since it is known that in a wave the magnetic force is always perpendicular to the electric force, the magnetic force will always be horizontal in this case. Further, it is known that the direction of travel of a wave is perpendicular to both the electric and magnetic force, and this direction will therefore be horizontal in the above instance (see Fig. 1 (*a*)). If, now, while keeping the direction of travel of the wave the same, we arrange that the electric and magnetic forces shall change places, as shown in Fig. 1 (*b*), we shall have obtained a wave which is horizontally polarised. A little consideration of the case of a wave in which the electric force is neither vertical nor horizontal will show that this can be resolved into two component waves polarised in a vertical and horizontal plane respectively.

Polarisation of Light

Now in the case of optics it can be demonstrated that ordinary white light consists of a collection of waves polarised in all directions in a plane perpendicular to the direction of travel, and the beam of such light waves is said to be " unpolarised." There are certain arrangements, however, which can be set up by which the effects obtained vary with the plane of polarisation of the light. Two such cases are the reflection of light waves from a plain sheet of glass, and the transmission of waves through certain crystals, such as tourmaline.

If a beam of white light is passed through a crystal of tourmaline the resulting transmitted light will be polarised in a plane parallel to what is termed the optic axis of the crystal. If the crystal is rotated in its own plane about the direction of the beam as an axis, no change in the intensity of the transmitted light will be observed. This is due to the fact that, whatever may be the direction of the optic axis of the crystal, the sum of the components of the vibrations of the white light in that direction is uniform.

Supposing, however, after having obtained plane polarised light from the first crystal we transmit this through a second crystal. If the second crystal has its axis parallel to that of the first a maximum proportion of the plane polarised light will pass through it. As the second crystal is rotated about the direction of the beam of light as an axis, the light passing through it will gradually diminish until when the axes of the two crystals are at right angles none of the light will pass through the second crystal. Such an experiment demonstrates the fact that no light can pass through a crystal with optical qualities similar to that of tourmaline, except that which has a component of vibration parallel to the optic axis of the crystal.

Polarisation of Waves from a Hertzian Oscillator

Let us now proceed to consider the nature of the polarisation in wireless waves such as we are ordinarily accustomed to deal with. Taking first the simplest case of the generation of waves by an elementary Hertzian oscillator, the directions of the electric and magnetic forces will be as depicted in Fig. 2. The lines of electric force (shown dotted) are seen to be in vertical planes parallel to, and intersecting in, the oscillator itself, while the lines of magnetic force are

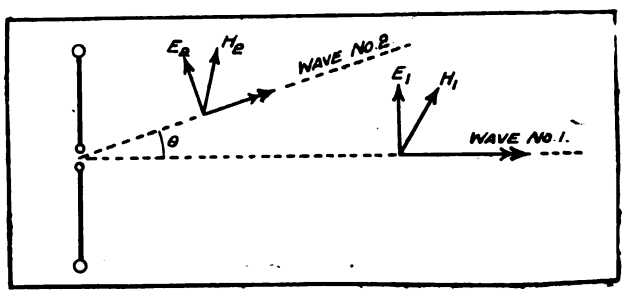

Fig. 3.—Directions of the electric fields E_1 and E_2 in waves radiated from a vertical oscillator. Both waves are vertically polarised.

horizontal circles with the centres at the oscillator. It is a fundamental condition that at every point in the space surrounding the oscillator the directions of the electric and magnetic forces shall be perpendicular to each other, while the direction of travel of the wave is at right angles to both of them.

If we consider the state of affairs at some distance

* *Note on plane of polarisation.*—The term " vertically polarised " is here being used in the sense in which it has become customary among wireless engineers and scientists. The plane of polarisation is assumed to be that containing the electric force and the direction of propagation of the waves. In optics by the definition which originated in the days before the electromagnetic theory had been developed, the plane of polarisation is that containing the magnetic force and the direction of propagation. While the existence of these two definitions may sometimes cause confusion in this subject, it is considered that in wireless matters it can always be made sufficiently clear that the plane of polarisation referred to is that containing the electric vector.

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from the oscillator, it will be found that in the horizontal plane through the centre of the oscillator the wave is travelling in a horizontal direction with the electric force vertical and the magnetic force horizontal. This case is illustrated as wave No. 1 in Fig. 3. In the same diagram wave No. 2 is shown as travelling in an upward direction at an angle θ to the horizontal, and while the magnetic force is still horizontal the

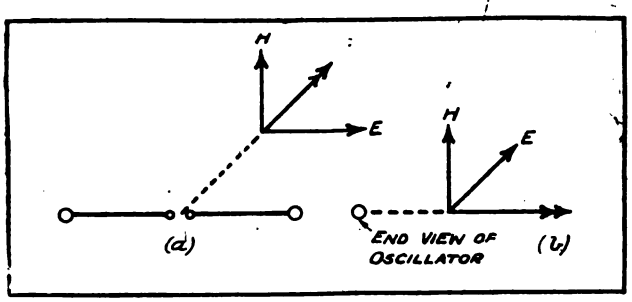

Fig. 4.—Directions of the electric and magnetic fields in waves radiated from a horizontal oscillator. In this case the waves are said to be horizontally polarised.

electric force is tilted backwards at angle θ to the vertical. As the angle θ is increased the intensity of the radiation decreases steadily, becoming zero in the vertical direction.

We thus see that the maximum radiation from this simple type of Hertzian oscillator, which is assumed to be oscillating at or above its fundamental wavelength, is in the horizontal direction, and that in this direction the electric force is vertical and the magnetic force horizontal. In the path of such a wave, therefore, the maximum e.m.f. will be induced in a vertical aerial or in a loop with its plane vertical and parallel to the direction of travel of the wave. No e.m.f. will be induced in an aerial which is entirely horizontal or in a horizontal loop. The simple oscillator is thus seen to radiate waves which are polarised with the electric force always in the vertical plane containing the direction of travel of the wave; in other words, the waves are vertically polarised.

Let us suppose now that the oscillator is turned so that it lies horizontally as depicted in Fig. 4 (*a*). The directions of the forces will have the same relation to that of the oscillator as shown in Fig. 2. In the horizontal direction through the centre of the oscillator the wave will contain a vertical magnetic force and a horizontal electric force (Fig. 4 (*b*)). This means that no e.m.f. will be induced in a vertical aerial or loop, and for maximum reception the aerial and loop must be arranged in the horizontal plane, the direction of the aerial being such as to be parallel to the electric force. The radiation from the oscillator in this position is now said to be horizontally polarised.

Polarisation of Wireless Waves from a Transmitting Aerial

In converting the ideal case of the Hertzian oscillator to the more practical case of an aerial connected to earth, we may first suppose that the aerial is a straight, vertical wire, and that the earth below has an infinitely high conductivity. It is, then, quite accurate to consider the aerial as half of an oscillator, the other half of which is formed as an image below the surface of the earth. The process of radiation from such an aerial is of the form depicted in Fig. 5, in which the half loops of electric force accompanied by the concentric circles of magnetic force are shown being thrown off from the aerial at each period of oscillation. It will be seen that at a distance of a few wavelengths from the aerial (as at point P) the electric force at the earth's boundary surface is vertical, and the magnetic force at this point will be horizontal and perpendicular to the direction of travel of the wave.

If the aerial possesses horizontal as well as vertical components, as in the inverted ┐ type, it is evident that the former will contribute to the radiation in such a manner as to give a horizontal electric force and a vertical magnetic force at the earth's surface. Illustrating the case diagrammatically in Fig. 6, the electric and magnetic fields marked E_2 and H_2 respectively, due to the horizontal portion of the aerial, will be superimposed on those marked E_1 and H_1, due to the vertical portion of the aerial.

But we must remember that a complete image of the transmitting aerial is formed below the earth, and that therefore the image of the horizontal portion will also contribute to the radiation. A consideration of the case as shown in Fig. 6 will show that at any instant the current in the horizontal member (2) of the aerial is exactly equal to the current in its image (3), and that therefore at the point P on the earth's surface the forces E_3H_3 due to the image will be exactly equal and opposite to those (E_2H_2) due to the horizontal portion of the aerial. In brief, there will be no horizontally polarised waves radiated along the earth's surface, and the forces in the waves set out will be those shown as E_1H_1, i.e., vertically polarised.*

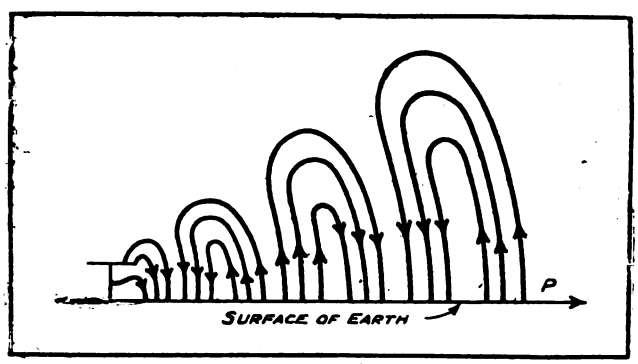

Fig. 5.—Form of the radiation from a vertical aerial connected to earth.

Another way of viewing the position is that the horizontal portions of the electric force and the vertical components of magnetic force create eddy currents in the earth, the secondary fields due to which are exactly equal and opposite to the primary fields in the wave, and thus eliminate these components at the earth's surface.

If, however, we are considering the radiation in an upward direction from the earth's surface—for example, towards the point Q—the distance of this

(*See footnote on page 530.*)

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point from the member 2 and its image 3 will not be quite equal, and there will therefore be a resultant of horizontal polarised waves in the radiation in this direction. In the case of short-wave working when the aerial may be operated at wavelengths below its

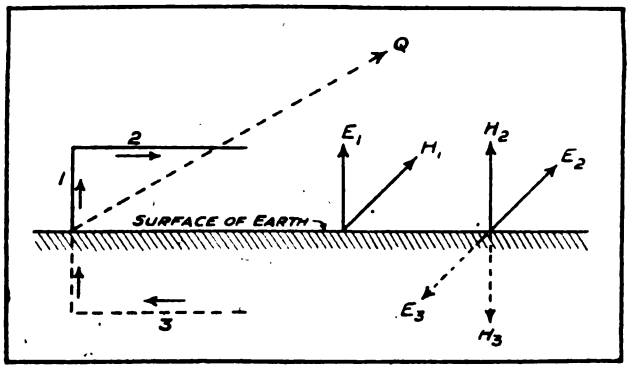

Fig. 6.—Diagram explaining the absence at the earth's surface of horizontally polarised waves in the radiation from an inverted ┐ aerial.

fundamental, or the distance between the flat top of the aerial and its image may be comparable with the wavelength, the consideration of the nature of the polarisation in the waves emitted becomes much more complicated than in the case considered above, and would need to be calculated for each specific example.

Effect of Finite Conductivity of the Earth

It will be noted that in the above discussion it was assumed that the earth possessed an infinite conductivity at wireless frequencies, a state of perfection which evidently cannot prevail in actual fact. The effect of an imperfectly conducting earth is to decrease the equivalent currents in the image, so that in the case shown in Fig. 6 the forces E_3H_3 will be less than those E_2H_2 due to the aerial. and there will therefore be a small residuum of horizontally polarised waves sent out along the earth's surface.

From our present knowledge of the conductivity of the earth, however, it can be shown that the currents in the image are only a few per cent. less than those in the aerial at wavelengths from 200 to 500 metres. We should expect to find that in the radiation received on the earth's surface from ordinary transmitting stations the great majority of the waves are vertically polarised. This deduction from theoretical principles has been verified experimentally in two ways: first, by ascertaining directly the plane of polarisation of the waves received from typical transmitting stations, and, secondly, by making two deliberate attempts to radiate horizontally polarised waves along the earth's surface.

Experimental Verification of the Theory

Some three or four years ago the writer, in conjunction with Mr. R. H. Barfield, developed methods for the absolute determination of the directions of both the electric and magnetic forces in wireless waves. These methods have been fully described elsewhere, and consisted in the use of both open aerial and closed coil receivers which could be oriented in any direction in space. An extended series of observations carried out with this apparatus has shown that the radiations received from various transmitting stations on wavelengths of from 20 to 12,000 metres are very accurately polarised in a vertical plane, so long as the transmission is in the daytime and free from the usual night or atmospheric phenomena.

As was mentioned in a contribution to the December number of TELEVISION, one effect of the finite conductivity of the earth is that the electric force of the arriving waves is not quite vertical, but is tilted forward slightly in the direction of travel of the wave. This forward tilt can be measured with the apparatus just referred to, but it is found that the angle of departure from the vertical is only a fraction of a degree on long waves, while its value is of the order of 3° on the medium of broadcasting band (wavelength 200 to 500 metres). In all cases it was found that the magnetic force was accurately horizontal or parallel to the earth's surface, so that no signals could be received on a horizontal loop.

Coil Aerial for Radiation of Horizontally Polarised Waves

In the first of the attempts made to radiate horizontally polarised waves the transmission was made from a large coil aerial arranged with its axis vertical (as shown in Fig. 7). The coil was actually a large aerial tuning inductance, whose dimensions were about 10 feet high by 6 feet diameter, and which contained forty-two turns. The aerial and earth connections were removed from the inductance, which was then tuned with a dummy aerial circuit to the required wavelength. In this condition a current of 36 amperes was obtained in the coil.

Now, such a transmitting arrangement radiates in two ways. First, owing to the vertical height of

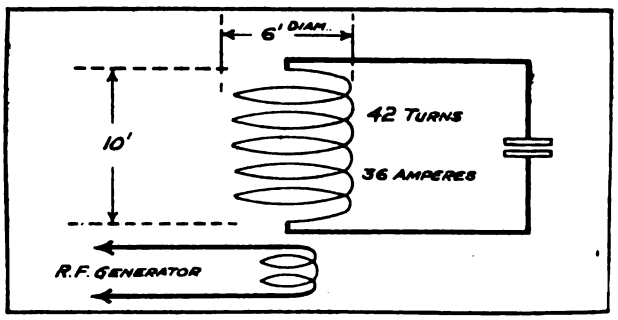

Fig. 7.—Arrangement of coil antenna used for experiments on the transmission of horizontally polarised waves.

the coil, it will act as an ordinary vertical aerial, which, although only 10 feet high, is carrying a current of 36 amperes. This part of the radiation will evidently be vertically polarised in the normal manner. Secondly, it will act as a coil transmitting aerial with its axis vertical instead of horizontal, as

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is usually the case. Although the radiation from a coil is known to be considerably less than that from an aerial, it must be remembered that this coil gave 1,512 ampere turns in a circular area 6 feet in diameter, and that therefore the magnetic field inside and outside the coil was quite considerable. The direction of this magnetic field is shown in Fig. 8, from which it will be seen that the waves emitted were horizontally polarised.

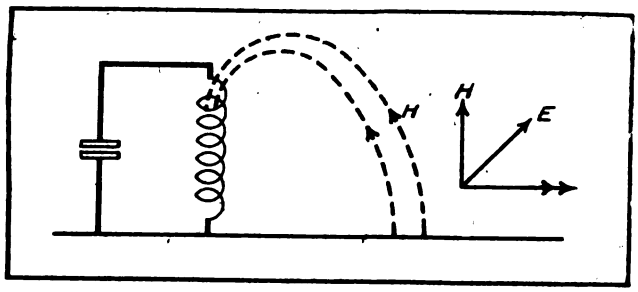

Fig. 8.—Direction of the magnetic field in the waves radiated from the coil antenna in Fig. 7.

It will be understood, therefore, that the radiation from this coil transmitter was a mixture of vertically and horizontally polarised waves, and that if these were transmitted equally well over the earth's surface the polarisation of the waves arriving at a distant receiver should have some direction intermediate between the vertical and horizontal. At a distance of nine miles from the transmitter, however, adequate signals could be received on either a vertical aerial or a frame coil, and the arriving waves were found to be vertically polarised. The horizontal component of the magnetic field was exactly at right angles to the direction of transmission, and no trace of a vertical component of the magnetic field could be found.

Horizontal Hertzian Oscillator

In the second attempt to transmit horizontally polarised waves a very large Hertzian oscillator was set up in a horizontal plane. The oscillator was actually the earth screen of a large transmitting aerial, which was removed for the purpose of this experiment. This screen was cut in two halves, which were then connected to the secondary circuit of a transmitter. By this means a horizontal oscillator was formed, whose dimensions were 600 feet long by 150 feet in width, the height above the ground being about 9 feet. A diagram of the arrangement is shown in Fig 9.

The natural wavelength of the system was found to be about 800 metres, and by inserting series condensers this was reduced to 450 metres, at which adjustment a current of about 4 amperes was obtained at the centre of the screen. Great care was taken to prevent the possibility of any vertically polarised waves being emitted. The coupling between the primary and secondary coils of the transmitter was made very loose, to reduce any capacity connection to earth, and the vertical portions of the "aerial" circuits were only 1 foot or 2 feet long, and even over this length the leads with current in opposite directions were run side by side with a spacing of a few inches, these distances being negligibly small compared with the dimensions of the screen.

The polarisation of the waves emitted by this arrangement was measured at two receiving stations distant 11·5 and 93 miles respectively. At both stations the waves received were found to be exactly similar to those from any other station, i.e., vertically polarised. While this result is perfectly consistent with those obtained in showing that horizontally polarised waves cannot be transmitted along the earth's surface, it may be wondered how it was that the waves became converted into those of the vertically polarised type.

One possibility is that the precautions taken to prevent vertical electric fields in the transmitter itself were not so efficient as they were considered to be. But another and more probable explanation is that the field in the neighbourhood of the transmitter was modified by the presence of various objects such as trees or metal-work in the locality. A long wire, for instance, which is neither entirely vertical nor horizontal throughout its length, would have a current induced in it by a horizontal electric force. Any re-radiation then taking place would introduce a vertical component into the original electric field, which would evidently form part of the total radiation of the whole system.

Conclusions

It may be fairly concluded that the above experiments provide adequate proof of the theoretical deduction that horizontally polarised wireless waves can

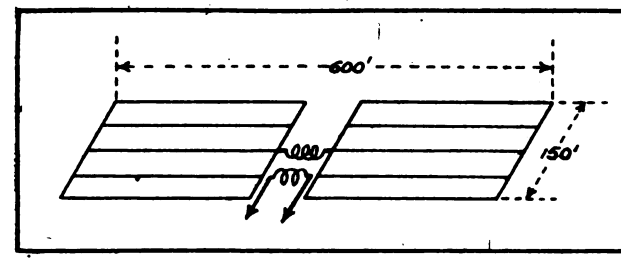

Fig. 9.—Horizontal earth screen supplied from a transmitter for the purpose of radiating horizontally polarised waves.

be transmitted over the earth's surface only with difficulty, if at all, and that the effect of such waves is entirely negligible compared with the effect of any vertically polarised waves emanating from the same transmitter. It must be remembered, however, that this does not preclude the practicability of projecting horizontally polarised waves upwards at an appreciable angle of elevation to the earth's surface. If subsequently these waves are deflected downwards from the upper portions of the earth's atmosphere, and their plane of polarisation is rotated in transit, it is evident that they will be detectable with a receiver employing a vertical aerial at some considerable distance.

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Sydney A. Moseley *on* More

IN the last issue of TELEVISION I exclusively gave the interesting news that the B.B.C. had arranged to give the Baird Company extended facilities for broadcasting. It is a piece of excellent news, and augurs well for the future.

Indeed, the whole atmosphere at Savoy Hill has undergone a change for the better, and I believe that the present technicians are more sympathetic with Mr. Baird's ideas than was the old regime.

Let us consider the effect of this announcement. Broadly stated, all it amounts to is two half-hours a week—that is to say, half-an-hour for two *nights*. This, however, is a step in the right direction, for many of us have insisted for some time past that the hours of broadcasting that had been placed at the Baird Company's disposal were not only inadequate but inconvenient. Most people are otherwise engaged at 11 o'clock in the morning when these transmissions take place.

In every respect a night transmission enables both the listener and amateur experimenter to take part in the transmissions.

The announcement of these conditions had an immediate effect on the public, as can be seen by the comments in the daily Press. What is more, a further announcement by the Baird Television Development Company that it was their intention to go into production at once pending an arrangement with the big manufacturers created great enthusiasm among those who were anxious to see television get into its fuller stride before the end of the year. By the time this appears in print I am hoping that the first televisors will be on the market.

The Next Move

This will enable readers to pick up living images of speakers and singers, but will not enable them as yet to get the sound simultaneously with sight. That is the next move, and I have reason to believe that the additional wavelength will be placed at the Baird Company's disposal before the end of February.

Again, as has been my habit all along, I am erring on the conservative side. With the granting of the two wavelengths television undergoes the great test from which I am certain, judging by what I have seen in the morning transmissions, it will emerge with every credit.

I should say that after a short period of night and morning transmissions the case for inclusion in the daily programmes will be irresistible.

So that after all, in spite of obstacles, unexpected handicaps, we were not far wrong in prophesying the event of television " within a few months."

A Concession Wanted

Readers of TELEVISION who have been loyal from the first will naturally expect some concession from the Baird Company so far as programmes are concerned.

I have not been officially informed, but I have grounds for hoping that this magazine will obtain special privileges in the way of publishing programmes in much the same manner as the *Radio Times* does on behalf of the B.B.C.

From correspondence that has reached me it is apparent that the broadcasting arrangements that are now obtaining are not sufficiently well known, as they should be. In order to clarify the situation, let me go over the position. Broadcasting of living images, pictures and reading matter takes place five mornings a week from 11 o'clock till half past. On Saturdays and Sundays there is no broadcast of television.

When television was first transmitted the Baird Company put over a varied programme which included singers and speakers, but it was found that the time spent in putting over song and monologue left little time for the purpose of television experiments, for which, of course, the time had really been allotted. The engineers wanted to test the lines and to ascertain the special conditions for broadcasting at 2LO. You must remember that, actually, the televised persons or objects are placed before the transmitter *at the Baird studio in Long Acre*, and this is sent by line to 2LO, from whence it is broadcast. Although those who were privileged to witness the first broadcast of television regarded it as extremely successful, the Baird engineers were by no means satisfied, and claimed the whole half-hour for television only. Bang went the rest of the programme.

That is what has been happening since the first broadcast. I did the announcing for some weeks, and it has now been taken over by Brigadier-General Russell ; but all that has been happening so far as the speech side is concerned is that an announcement,

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Facilities

brief and to the point, that a television experiment is being broadcast. Indeed, I will give you the sort of thing that is being put over :—

"This is the Baird Television Development Company calling from the studio at 133, Long Acre.

"We are continuing to-day our experimental television broadcasting by the Baird process.

"Those who were looking in at the same time yesterday will have been able to see some living persons sitting in front of the television transmitter. We hope that the 'lookers-in' will almost have been able to imagine that they were face to face with these persons as they watched every movement and expression. We then showed the skull of a tiger, between the teeth of which a man inserted his head. This was followed by some handling of playing cards, first with a large one and then with others from a pack of ordinary size. A portrait of the King concluded the programme.

"Our experiments to-day will be of the same character.

"Stand by now, please, for to-day's experiments."

The Closing Announcement

Then the closing announcement would be something like this :—

"Baird Television Development Company calling.

"This concludes to-day's experiments.

"We shall be transmitting at the same hour to-morrow, but before concluding this announcement to-day I would like to remind all 'lookers-in' of the request we make every day that they will be so very good as to report the results obtained to us at our Head Office at 133, Long Acre, W.C.2."

Then one of the engineers, or a typist, or a telephone operator sits before the transmitter and his or her face is picked up at various parts of the country. Mr. Baird, for instance, has a televisor at his house at Box Hill, and he is able to watch the experiments from there; engineers at Hendon also check the transmission, and of course there are amateurs in different parts of the country trying to make the most of it, probably with a disc that by no means fits the bill. One amateur came from a long distance, walked into the studio in Long Acre and pointed to a member of the staff, saying, "Yours is the face I picked up in my home." And he was right. It was a great moment for him, and certainly for those engineers who had been labouring hard to make the experiments a success.

It was the intention of the Baird Company not to proceed with the manufacture of televisors until these experiments had shown them pretty definitely that reasonable results could be obtained from such an apparatus when placed on the market. That moment has now come. The advantage of utilising the half-hour exclusively for the purpose of experiments in television is now apparent, and by the time this is in print a good many readers will have had the opportunity of purchasing the first televisors ever placed on the market in this country. So is history made.

"A Matter of Business Strategy"

Indeed, it becomes now a matter of business strategy. The labour which many of my readers, united with my own, expended in order to obtain official recognition and the means of transmission have borne fruit. It is up to the commercial side of the Baird Company to show us now that this division has not been in vain. Readers of TELEVISION will watch developments with the closest attention and with the keenest interest.

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Television *and* Your Wireless Receiver

PART II.

By *H. J. Barton Chapple*, B.Sc. (Hons.), A.M.I.E.E.

IN analysing our wireless receivers to see whether they are capable of producing signals for efficiently supplying and operating a Baird Televisor, we left off Part I at an interesting juncture by querying "Which is best?" The details of grid leak and anode bend recification had been explained and it was necessary to take all these points into consideration before coming to any definite conclusion.

A reference to Fig. 1 will show that the peak value of the signal may be as much as twice the normal value of the carrier wave. Thus, in order to avoid the flow of grid current which in this method of rectification would introduce distortion, it is essential either to have some means of regulating the strength of the signal applied to the detector grid, or, alternatively, use sufficiently large values of high tension and grid bias that grid current does not flow. With strong signals, grid leak rectification causes distortion and in consequence is only efficient with a relatively weak input. On the other hand, the reverse is the case with anode bend and the input must be so large that with normal values of modulation only the straight part of the characteristic is used.

A Factor of Great Importance

Now consider for a moment what should be the factor of greatest importance in a receiver that is going to "deliver the goods" in the form of television entertainment. Why, a complete absence of distortion, of course. Very well, how are we going to make the absence of distortion compatible with adequacy of signal strength and yet keep the number of stages in our receiver within economical limits? Obviously we have two possibilities open to us, namely, either use a form of reaction control to boost signal strength, or employ high frequency amplification. But we know from previous experience with aural reception that the prodigal use of reaction control to boost signal strength has done more to mar the quality of reproduction than a poor loud-speaker, and if excessive reaction (and even moderate reaction in many cases) spoils the listening quality, how much more so is it going to impair the quality of a received picture?

The Best Solution

Obviously, the best solution lies in the use of high frequency amplification and a reduction, or, where possible, a complete absence, of reaction control. With one stage of the modern screened grid valve efficiently designed it is possible generally to bring in all the broadcasting stations which are really worth listening to. Those stations that demand reaction almost to oscillation point and hairline tuning are seldom worth the candle for entertainment purposes, and certainly would not be worth looking at from the television point of view.

Reasoning on these lines, we can see the advantage of a good high frequency stage in front of our detector valve and for a given *arial* input the more efficient the H.F. stage, the greater the signal input to the grid of the rectifying valve. Now we have seen that such strong signals demand an anode bend system of rectification to give distortionless results, and generally this will be found to be the case. A further reason for preferring this system was indicated

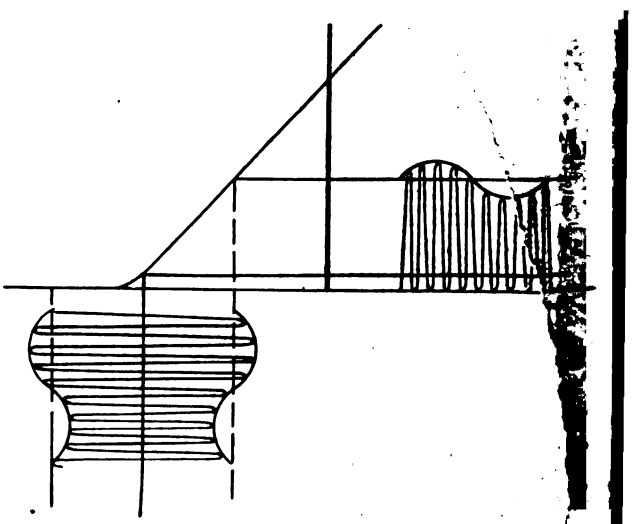

Fig. 1.

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in the previous article, namely, the likelihood of frequency distortion with grid leak rectification; so taking all these points into consideration it is plain that for the best results anode bend is to

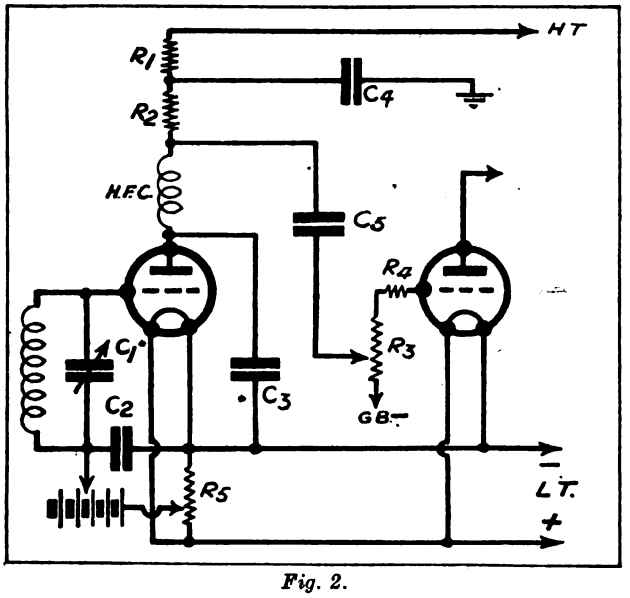

Fig. 2.

be preferred. This must not be taken as indicative of the ruling out of grid leak rectifiers; that, of course, would be ridiculous. I am merely stating a logical deduction which proves that for the *best* results anode bend should be the choice.

Detector Details

One of the greatest mistakes generally made with this rectifier (that is, the anode bend) is insufficiency of high tension and grid bias or the employment of a valve having too high a magnification factor. A very satisfactory solution as far as television reception is concerned is the use of a detector valve of moderate impedance and follow this with a resistance capacity coupling. Bear in mind that by increasing H.T. and G.B. within the rated limits of the valve it is possible to deal with high frequency inputs of any magnitude sufficient to obtain with the minimum of low frequency stages an output which is wholly adequate for working the neon of the televisor.

Be careful that the output circuit from the detector is properly designed, and it is invariably a good plan to include an anode bypass condenser—see the condenser C_3 of Fig. 2. Do not make this too small. I find it an excellent idea to use one of the semi-variable class, such as a Formo-densor of .0003 to .001 mfd. capacity range. Adjustments can then be made under working conditions to secure the best results. The inclusion of an H.F. choke will guarantee an adequate bypass through the condenser, and with R_2 as the plate resistance for the resistance capacity coupling and R_1 and C_4 the decoupling arrangement to ensure an absence of battery feedback or motor-boating, the scheme has proved admirable in practice.

When making your adjustments of high tension and grid bias to ascertain the best working point for anode bend rectification, don't make the voltage "jumps" on the H.T. too large. Remember that a small grid volts change is equivalent to a much greater plate volts change, so the smaller the H.T. steps the better will be your chance of finding the right setting, and from time to time this may with advantage be checked up owing to a slight alteration in valve characteristics possible occurring from valve age.

Useful Controls

Take care not to overlook that a form of volume control on the high frequency side is really necessary, and this can be done simply by the inclusion of a rheostat in the filament circuit of the screened grid valve. Again, it is very often an advantage to have a volume control after the detector valve in addition to any arrangements made preceding this valve, and for this an excellent plan is the use of a variable grid leak in the form of a potentiometer connected in the grid of the first low frequency valve, shown as R_3 in Fig. 2. The value of this vernier control may be either zero to half megohm or zero to one megohm, depending upon the value of the coupling condenser C_5 used. Another refinement, often advantageous, is the inclusion of a stopper resistance R_4, a fixed grid leak of the order 100,000 to 250,000 ohms being suitable. Of course, the use of a potentiometer R_5 of, say, 400 ohms resistance across the L.T. supply gives the desired grid voltage gradation which is advisable with anode bend rectification.

Before proceeding to a consideration of the low frequency side of the set it is as well at this juncture to give attention to the high frequency side. A circuit which is too selective is not best for television, as it must perforce cut off the sidebands in fulfilling its function of selectivity. Provided it gives reasonable selectivity then all will be well. It will be appreciated that there are many ways in which a screened grid valve may be coupled to a detector valve, but I am inclined to the belief that choke capacity feed is capable of giving about the best results under normal working conditions. Some may prefer a plain tuned anode arrangement for inserting in the

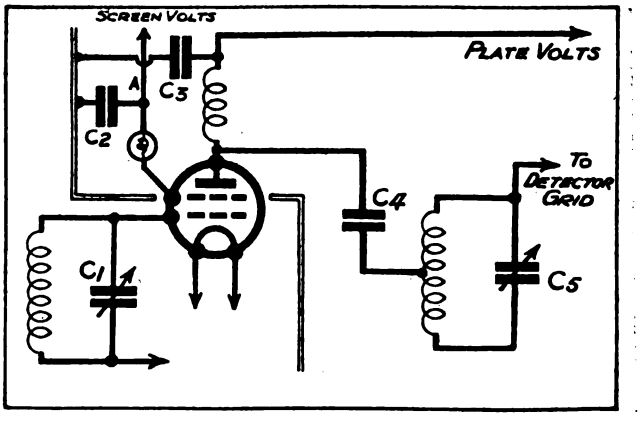

Fig. 3.

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plate circuit of the screened grid valve because of the high H.F. impedance resulting from this combination, while others show preference for a tuned secondary H.F. transformer coupling. By properly choosing the H.F. choke to insert in the screened grid plate circuit, however—and there are many now on the market with high impedances specifically designed to meet this need—and ensuring that its natural characteristics differ from those of the high frequency choke used in the plate circuit of the detector valve, then satisfactory results will accrue.

A Suggested Scheme

One such scheme that I have in mind is sketched in Fig. 3. The value of the coupling condenser C_4 should be about ·001 mfd., and this condenser may be joined to the centre or grid end of the tuned coil according to the measure of selectivity desired. The provision of bypass condensers C_2 and C_3 of, say, 1 mfd. capacity is really sound practice and gives a measure of stability often found wanting in receivers of this type. Note the inclusion of a safety fuse in the screen grid lead as a precautionary measure against valve failure. Should by chance the valve prove faulty and the screen grid touch either the valve filament, normal grid or plate, there will be a short circuit of a portion of the high tension supply, and this must be guarded against. A low consumption bulb of the 60-milliampere class is admirably adapted for this purpose, but take care to include it on the grid side of the bypass condenser C_2 as shown in Fig. 3. If placed in the position marked *A* it will be subjected to the charging current of this condenser and often blow when the set is switched on.

In Passing

There are many important points to consider in connection with screened grid valve circuits, and it will be advisable therefore to defer these until next month. Of course with the present magnitude of power used in the Brookman's Park transmissions of Baird television, the inclusion of an H.F. stage will be wholly unnecessary for anyone working his set within reasonable distance of the station. An anode bend detector without reaction used on quite a small aerial and coupled to a good low frequency amplifier gives excellent results at quite distant places, but it is as well to bear in mind that other stations on the Continent, and in Ireland especially, will be transmitting soon (Witzleben is already on the air morning and afternoon) and the possession of a more powerful set would give a choice of " seeing in " programmes.

CATALOGUES RECEIVED.

From Messrs Isenthall & Co. Ltd., Ducon Works, Victoria Road, North Acton, London, W.3 we have received an interesting eight-page brochure giving details and prices of " Carola " Photo-Electric Cells and Vacuum Relays. They also give particulars and price of a Kerr Cell.

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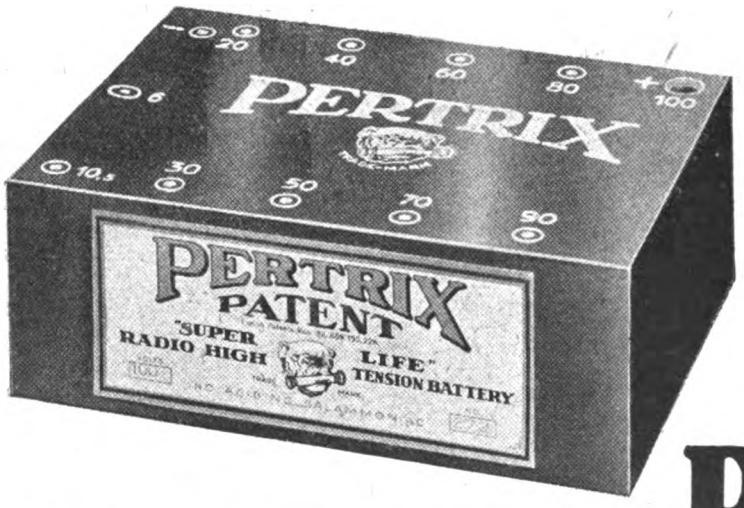

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The Story of Electrical Communications

by

Lt.-Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

PART XIII.

POINT-TO-POINT WIRELESS (I)

WE have discussed the applications of wireless signalling to the communications of ships in some detail, as in this particular province it has no competitor for communications beyond visual range, and its applications become, therefore, not only important but unique.

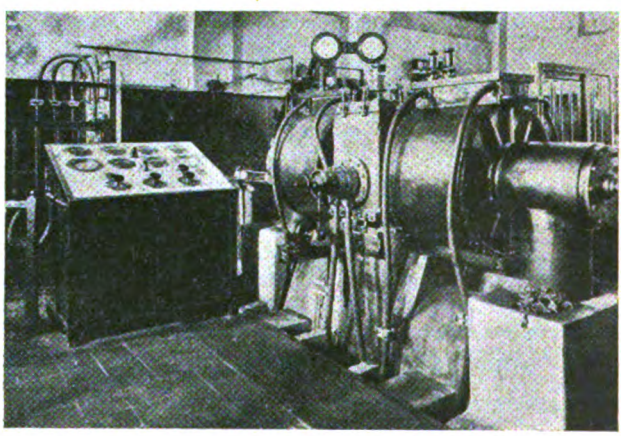
The same cannot be said when we turn to communications between places on land, because, as we have seen, all great centres of population throughout the world were linked together by telegraphy, and many of them by telephony, long before Marconi introduced wireless signalling as a practical means of communication. The field was already well exploited and the new-comer had to show clearly in what ways it might be superior to the old-established systems before it could hope to receive adequate financial backing.

Early Days

At first, progress was slow, and it was said that wireless might be useful for land communications in out of the way parts of the earth where the ordinary line telegraph was impracticable, in fact in those places where it was pretty obvious that it could not possibly pay its way; so that was not much help. The War Office saw at once the great potentialities of wireless for point-to-point working in military operations, and sent out sets to the Boer War which was then in progress. The whole thing, however, was so much in the experimental stage in those early days that results were disappointing, though enough was done to show military authorities throughout the world that it was only a matter of time before wireless would rank as one of the most important, if not indeed the most important, means of communication on the battlefield. The time came all right in 1914, but it is outside the scope of these articles to consider the development of electrical communications in war. Let us return then, to the commercial aspect.

Point-to-point communication was already so well catered for by the telegraph, the submarine cable and the telephone that some markedly spectacular result was essential for the stimulation of public imagination, a necessary preliminary for introducing a new invention to a field of action already occupied.

This spectacular result was supplied by Marconi sending wireless signals for the first time across the Atlantic in 1901, and this event marks the entrance



A high-power arc transmitter as installed at the stations of the old Imperial Scheme at Oxford and in Egypt.

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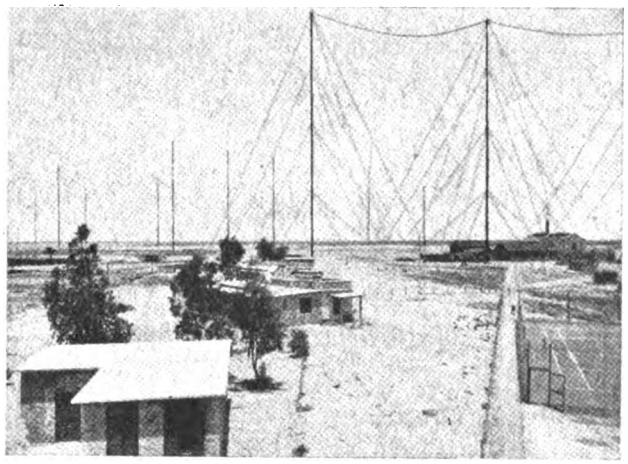


The old arc station at Abu Zabal, near Cairo, finished after the war.

of wireless on to the stage of point-to-point communication. It was a fine entrance, but many years were to elapse before it had any appreciable effect on the actors who were already in possession of the stage. There were various reasons. The old actors were doing very well, whereas the new one suffered from serious technical ailments, and, what was much worse, was soon wrapped up in a choking fog of financial jugglery. The former was inevitable with a new invention, but the latter was not, and to it must chiefly be ascribed the slow initial development of point-to-point communication by wireless signalling. There would be no advantage now in peering through that old financial fog, but it may be of interest, and is certainly much easier, to have a look at the technical ailments.

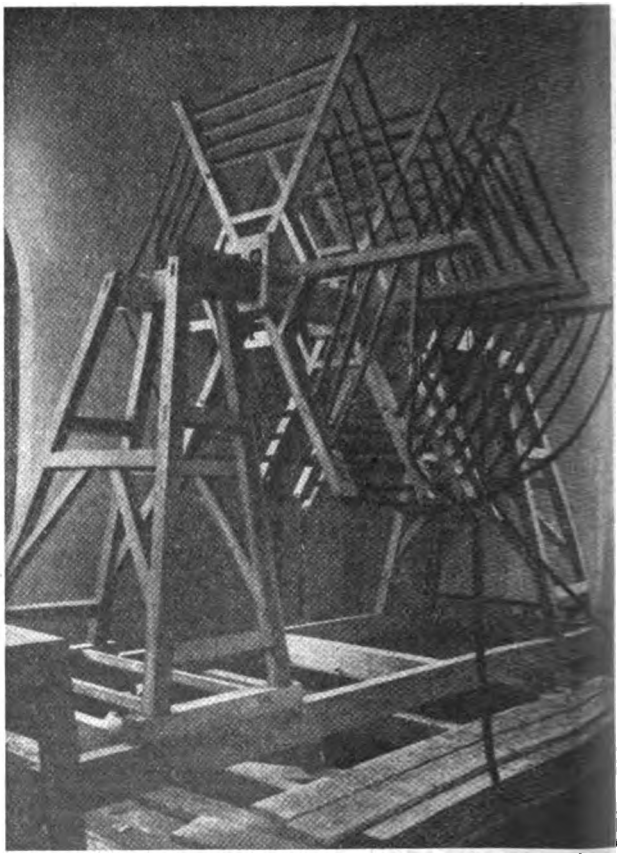
Wireless versus Cables

The principal technical drawback to long distance wireless telegraphy compared with the submarine cable was its unreliability. Sometimes communication was good, but at other times it was poor or even failed altogether, so that it was impossible to predict what sort of communication would be established at any given time. Such a state of affairs was hopeless for commercial success in competition with a cable which gave regular steady communication throughout the twenty-four hours. Reliability is essential for successful commercial communication, and this the wireless route could not give.

It was far cheaper to install, but its running costs were greater, and its unreliability put it out of court as a serious competitor with the cable. This drawback did not hold good for short range working, but there was no room for that. The world was already well supplied with short distance cables, and all civilised countries had a network of inland telegraphs. Wireless did, indeed, find an opening for inland work in sparsely populated areas, but it had little encouragement there from the commercial point of view.

Another great technical drawback was that wireless messages between two places interfered with wireless messages between other places within range, unless the wavelengths used were greatly different. The number of wavelengths available was small, so that the possible number of point-to-point channels was small; far too small to allow of competition with inland telegraphs. This drawback, like the former one, has of course lessened as wireless has developed, but it is still far too serious to allow of any competition with inland telegraph lines in a small country. It is, in fact, so serious that point-to-point working by wireless between places in this country has never been permitted by the Government.

The conditions are rather different in a large country like the United States, and still more different on the continent of Europe where the inland lines run through a number of different countries. In the former case there is some opening for wireless, due to the extent of the large area available, and in the latter case direct communication by wireless between distant places has the additional advantage of cutting out the expense of meeting the transit charges imposed by the various countries through which the land lines pass. There has developed accordingly of late years a considerable number of wireless point-to-point services in America and in Europe, including services between England and the Continent.



The main transmitting inductance at Rugby radio.

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The charges made for communication between this country and the Continent are the same whether the route used is by wireless or by cable and land lines, but the fact of having the two routes available in many cases ensures a better service. The charges for most of the really long range wireless services, including the Beam Imperial Services, are less than the cable charges, and we have seen in a previous article how the success of these Beam services seriously affected the position of the cable companies, and resulted in a combination of cables and wireless for Imperial communications.

The Merger

The development of wireless for point-to-point communication was thus confined, from the start, to long range working, and its main trouble was unreliability. At first, efforts were made to overcome this trouble by increasing the power at the sending end, and the sensitivity of the receiving apparatus at the receiving end. The increase of power involved larger aerials and longer waves; the increase of sensitivity involved better receiving instruments and directional aerials. This indeed sums up the first 10 years of technical advance in point-to-point communication. Then came the introduction of continuous wave transmitters and valve receivers, and for the first time the cable companies saw the red light; dimly it is true, but the glow was there. By 1928, when the Post Office had established the commercial success of Marconi's short wave Beam System, the glow became a flame, and the cable companies in this country saw that, unless they swallowed up the wireless, the game was up. The whole matter was considered by the Home Government, the Dominions and India, and, as described in a previous article, it was decided to merge the cable and wireless interests of the Empire into a new company which would be subject to a certain amount of Government control. The transfer to the new company took place at the end of September last, and, so far as our Imperial communications are concerned, wireless, cables and line telegraphy, the old rivals, are now advancing hand in hand.

The traffic work of this new commercial merger is in the hands of the Imperial and International Communications Co. Ltd., the manufacturing work being in the hands of an allied company, Cable and Wireless Ltd. The combined capital of these companies exceeds £53,000,000. This is the first great merger of cable and wireless interests in the world, but there seems to be a desire in the United States for some similar combination between cables and wireless there, and a strong move to get rid of legal restrictions which at present stand in the way of such a combination has been in progress for the last year.

The Imperial Chain

In the case of wireless telephony the circumstances were altogether different as there was no question of competition, for the simple reason that long range submarine cable telephony was still an unsolved problem, though, as we have already seen, this state of affairs is not likely to last much longer. Wireless telephony, therefore, was not included in the merger company's activities, and remains, as hitherto, in the hands of the Post Office.

But we have got too far ahead, and must return for a moment to glance at the developments which led up to the present arrangements. We have seen that Marconi's inauguration of the transatlantic service was the real beginning of point-to-point wireless telegraphy, and that for several years technical difficulties kept it far behind the cables. By 1912, however, this particular service, along with a few others which had been established subsequently in other parts of the world, was giving a really satisfactory service, though of course not up to the cable standard, and the Government decided to embark on a scheme for linking up the Empire by a chain of high power stations.

This scheme unfortunately got mixed up at the outset in the financial jugglery to which we have already referred, and it was not until the following year, after a stormy Parliamentary passage, that an Agreement was come to between the Post Office and the Marconi Company for putting the work in hand.

Stations were to be erected by the Company for the Government in England, Egypt, Kenya, India, Singapore, Hongkong and Australia, but the outbreak of war in 1914 held up the scheme.

The War

The erection of the English and Egyptian stations had been commenced, temporary apparatus was installed, and a certain amount of use was made of them during the war; but otherwise the scheme was stillborn, and no further attempt to erect high power stations was made by this country during the war. We were well supplied with cables and relied on these for world-wide communications. Our allies, however, were differently placed in that respect, and a number of high power wireless stations were erected during the war in the United States, France and Italy. This was the period when Arcs and Alternators came into use for transmission, and the Valve for reception; it was the time of the first red glow for the cable companies, but they were far too busy to take much interest in it just then.

As soon as the war was over, however, the glow became apparent, and the cable companies went all out to increase their carrying capacity. In a previous article we have seen how they succeeded in doing so by the invention of loaded cables, new magnifiers and regenerators, improvements which more than counterbalanced the technical strides which had been made by wireless in the war, and which placed the cables again in an apparently impregnable position so far as competition with wireless was concerned. But point-to-point wireless got busy too, in fact very busy indeed, and in the next article we shall trace its rapid development from the war to the present day.

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Feminine Reflections

Behind the Scenes

By *Nancy Debenham*

I'VE gone all modern! Wireless, talkies, the R101—they're all as out of date as last year's hat now, cos I've just been behind the scenes in a television factory.

Is that right?

Or should it be called something more elaborate and scientific?

Anyway, it was Mr. Baird's place in Long Acre where all the television experiments are made.

Believe me, the most elaborate, up-to-the-minute wireless set, complete with seventeen valves, four loud-speakers, central heating and a cocktail bar, would impress me just about as much as a horsehair sofa draped with a soiled antimacassar after that visit—but perhaps I'll get over it. I hope so, for the sake of poor Cecil, my own pet wireless at home, for whom I have bought some new valves for a birthday present.

In the Chair

It's so awkward when one is introduced to something quite new but which one *ought* to know something about. I am never sure of the correct attitude. "*Reahlly!*" sounds so inadequate when one is told in a matter-of-fact way that pictures can be transmitted for thousands of miles by means of a spot of light. "Coo!" or "Blimy!" are both rather coarse.

Personally, I contented myself with an occasional noise that might have meant anything, as the demonstrator airily touched on the various miracles that can be performed by means of television. Then I coyly asked to be shown over the works. (There I go again!)

I was immediately ushered into a dark, mysterious-looking room hung with curtains, and did not know whether to scream for help or join hands in a circle and wait for "manifestations." I did neither; but just assumed an expression of intelligent anticipation and waited. "Masterly inactivity" is always the best line in an emergency.

My "intelligent anticipation" label was not so good as I thought, however, for the demonstrator told me gently, for all the world as if I was at the dentist's, "not to be alarmed."

Another thing with a "dentist" flavour was the grim chair with its seat turned towards a sloping mirror and a dark glass arrangement in which I was invited to sit.

Plucking up my waning courage, I obeyed, and a dazzling spot of light played over my face. "That's how we televise you," gaily announced the demonstrator. His bedside manner had vanished and he had the air of a conjurer at a party, who had just brought an extra number of rabbits out of a hat.

The Wheel Goes Round

I was fascinated; and fished for an invitation to penetrate still further behind the scenes. Unlike most conjurers, these dear souls were delighted to show me exactly how it was done. "I want to see the wheels go round," I exclaimed kittenishly, having recovered my native verve. "So you shall," said the demonstrator, and sure enough I did; at least I saw one wheel go round at an alarming rate. It was in front of the magic-lantern arrangement (oh! how offended Mr. Baird will be when he reads this!).

"That's the worst of women," he'll say. "How *dare* she call my lovely projector a 'magic lantern'?") Anyway, there was the wheel, and when it stopped whizzing I was shown lots of little holes in it. "Just as wireless transforms sound into electricity, so does television turn light into electricity," said a learned young man in charge of the wheel. "The light shines through the holes in the wheel on to the Televised Victim in the chair out there" (pointing to the Chamber of Horrors outside), "scanning the subject twelve times in every second—and there you are."

Um, yes—I know, but *where* was I?

"Marvellous"

That is what I thought, but I only said "*Marvellous*" in an awed and (I hope) understanding voice.

"I do hope everything is clear to you now," said my demonstrating guardian angel when I had asked dozens of questions about various gadgets and mysterious cabinets littered about the walls and on the shelves in this Holy of Holies.

"Oh, yes—*quaite, quaite,*" I exclaimed gratefully, as I took my leave.

It was! Clear as mud on a foggy night in December!

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The Origin and Progress of Television

PART II

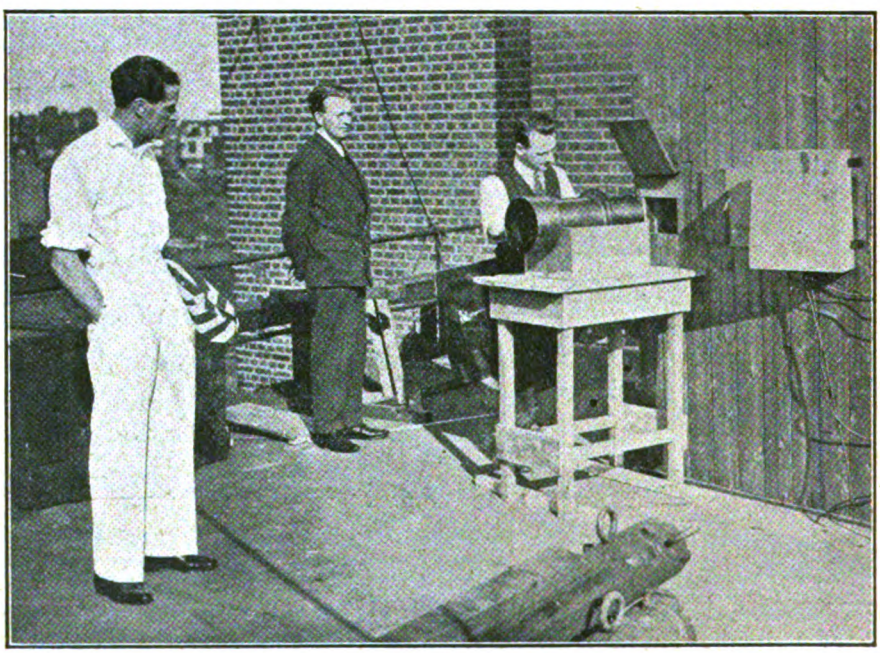
By *Clarence Tierney*, D.Sc.

IN the previous chapter the writer examined the available evidence concerning the original invention of the apparatus whereby television became possible and of practical application, and found that upon four fundamental facts: (1) the original discovery and first practical demonstration of television; (2) the first trans-Atlantic transmission and reception; (3) the first communication by television with a ship in mid-ocean; and (4) the longest recorded line communication, the incontestable priority both of invention and demonstration belonged in all cases to J. L. Baird.

Let us now examine some significant developments which have arisen out of these fundamental achievements. It was found in the very early stages of the discovery that one of the greatest hindrances to the development of practical television was the difficulty of obtaining absolute synchronism between the transmitting and receiving instruments, and it was not until this problem was satisfactorily and adequately solved that television attained the practical commercial application that it has to-day.

An examination of the published work upon this problem shows that it had intensively engaged many minds and laboratories in this and other countries, but for the sake of brevity I need not enter here into an examination of the failures of the several methods attempted by the various workers. It will be sufficient to observe that the first and only satisfactory solution was the auto-synchronism method developed by Baird in which he utilised the impulses of the glow discharge valve of the receiver, whereby electromagnetic control is effectively obtained.

The first public demonstration of a self-synchronised television receiver took place at the Radio Exhibition in 1928 (by wire), and the first public wireless demonstration of a self-synchronised television receiver, working under commercial conditions, took place before the Postmaster-General and a representative and officials of the B.B.C. and post office, when television was transmitted from Savoy Hill (on March 5th, 1929) through 2LO, and received at St. Martin's-le-Grand and simultaneously at the B.B.C. headquarters, no separate synchronising channel being used, but only the usual broadcasting facilities as used for speech. Only one wave-length was employed for television and synchronising, 2LO being used. Speech was transmitted and received



Jack Buchanan, the well-known actor, posing before Baird's daylight television transmitter.

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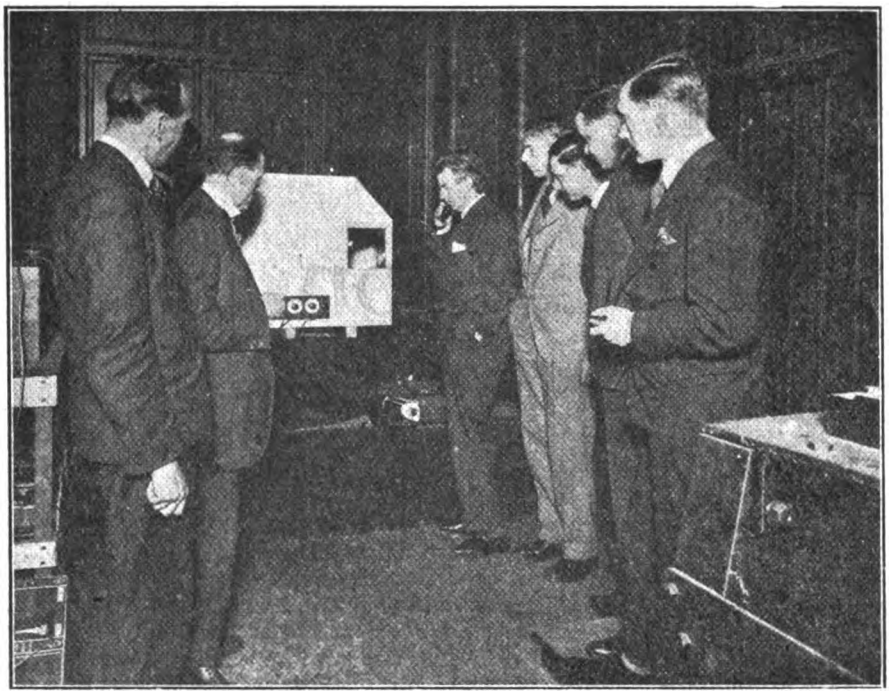


Daylight Television Reception.

simultaneously, using a separate wave-length.

Prior to this demonstration it had been maintained by the majority of critics that a special wave-length was necessary for synchronism, and that television, therefore, was not commercial. This demonstration proved beyond question that the television impulses themselves could be used to obtain complete synchronism. Baird was the first to demonstrate this practical solution of the synchronising problem, which had proved the greatest barrier to commercial television.

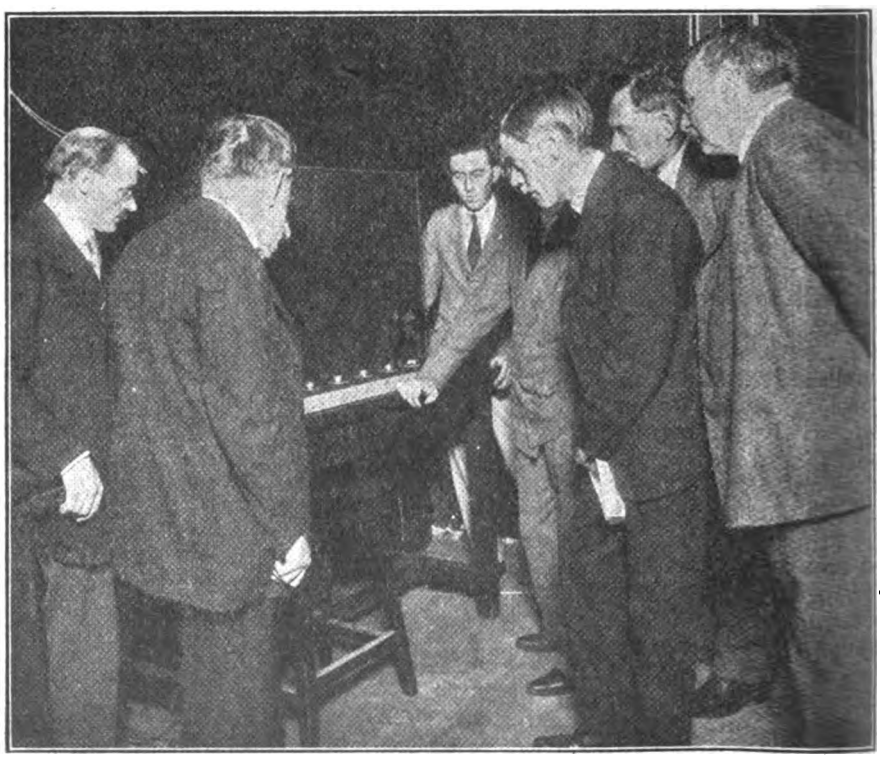
These facts are adequately attested, and in *The Times* of March 28th, 1929, an official letter was published from the Postmaster-General referring to the test demonstration by wireless which he and others had witnessed. In this letter it is stated that in the Postmaster-General's opinion the (Baird) system represents a noteworthy scientific achievement. The letter also records the following facts:

"The Postmaster-General has considered the results of the recent television demonstration in conjunction with the British Broadcasting Corporation and his technical advisers, and he has reached the following conclusions, which accord generally with the opinions of those who witnessed the demonstration. The demonstration showed that the Baird system was capable on that occasion of producing with sufficient clearness to be recognised the features and movements of persons posed for the purpose at the transmitting point."

Equally notable in the rapid sequence of these phenomenal developments was the television of subjects illuminated only by diffused daylight, the first demonstration of which was given by Baird early in June, 1928; and in TELEVISION for the following month we read, from no less an authority than Sir Ambrose Fleming, F.R.S.:

"The writer has had the opportunity of seeing in practical operation in Mr. Baird's laboratory a very striking advance in the apparatus for television which has been recently made by Mr. Baird.

"In this vast improvement it is not necessary for the face or object, the image of which is to be transmitted for television or 'televised' (if one may



Interested members of the British Association watching a demonstration of colour television at Glasgow, September, 1928.

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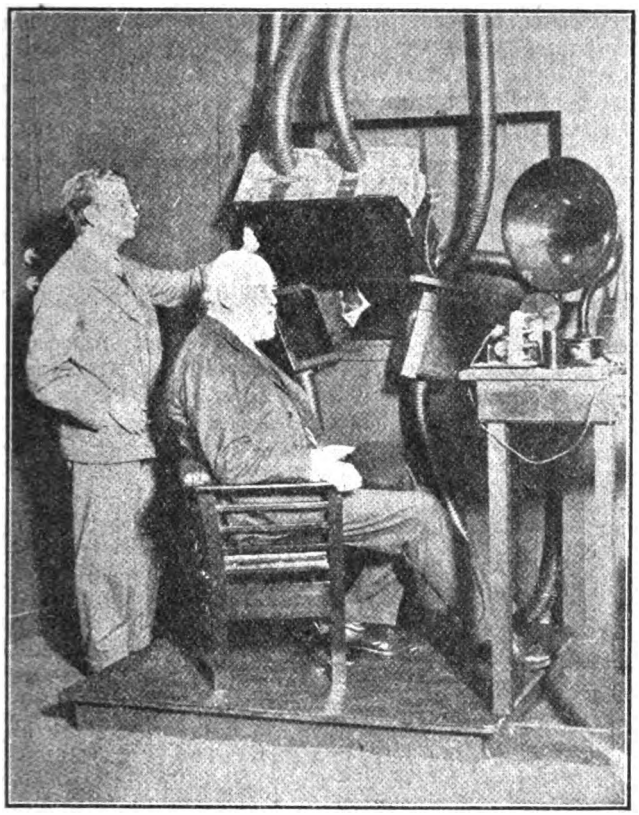


Sir Oliver Lodge and Mr. Baird photographed before the latter's noctovisor at the Leeds Meeting of the British Association in 1927.

venture to coin such a word), to be scanned by a brilliant beam of light traversing it, or to be flooded by powerful infra-red rays as explained below. The object whose image is to be transmitted can be simply placed in diffused daylight, just as if the ordinary photograph of it had to be taken. The transmitting apparatus is then placed near to the object, and the image of it appears on the screen at a distance when proper synchronism is secured. The advantage of this important advance will be clear. It means that the face of a singer or speaker can be transmitted by television at the same time that the voice is being picked up by a microphone for ordinary wireless broadcasting. It means a great step forward in the possibility of transmitting to a distance the image of moving objects or persons as seen in ordinary daylight, without exposing them to rapidly moving beams of light, or to dazzling illumination or dark heat radiation.

" The television transmitter becomes, in fact, a more complicated kind of camera, in which the screen on which the image appears is not immediately behind the lens, but may be miles or hundreds of miles away."

Major Archibald Church, D.S.O., M.C., another competent witness writing in TELEVISION for August, 1928, reports :

" On June 18th I was again invited to the (Baird) Long Acre laboratory to further demonstrations. In the first one the persons were seated on the roof in front of the transmitter, the object being illuminated only by daylight. (Incidentally it was an exceptionally dull day.) *At the receiver I had no difficulty in distinguishing between the features of one person and another, or in detecting their slightest movement, there was, in fact, more detail observable than I had seen at the February demonstration when the object was artificially illuminated.*"

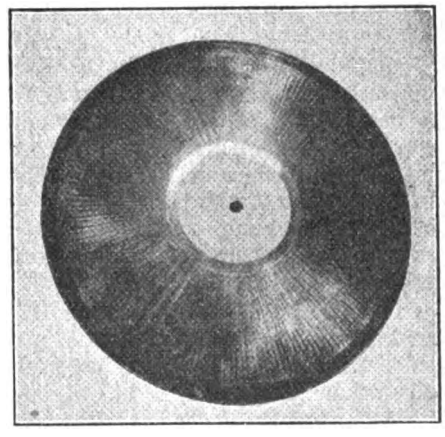
Still another remarkable chapter in this romance of applied physics was opened when the television of objects in natural colours was made possible for the first time through the same inventive genius. Thus we find that in July, 1928, Baird had solved this problem and gave demonstrations of transmitting and receiving objects in their natural colours with remarkable fidelity. In *Nature* of August 18th, 1928, which describes the method, we read :

" The colour images we saw which were obtained in this way were quite vivid. Delphiniums and carnations appeared in their natural colours, and a basket of strawberries showed the red fruit very clearly."

A further interesting and novel development was achieved in the following month, August, 1928, when Baird first demonstrated television in stereoscopic relief. Professor F. J. Cheshire, C.B.E., describing this demonstration in TELEVISION of September, 1928, says :

" These pictures, when viewed by an ordinary stereoscope, gave a picture in relief of the object—a human head—transmitted. In this simple way has another milestone been passed on the way to the achievement of that magical combination of the wireless transmission of perfect hearing with that of perfect seeing."

It is also recorded that Baird gave demonstrations of both colour and stereoscopic television at the meeting of the British Association at Glasgow in September, 1928.



A Phonovision Record.

It would be a regrettable omission were no mention made in this review of two remarkable and noteworthy developments intimately connected with television. I refer to what are known as Noctovision and Phonovision.

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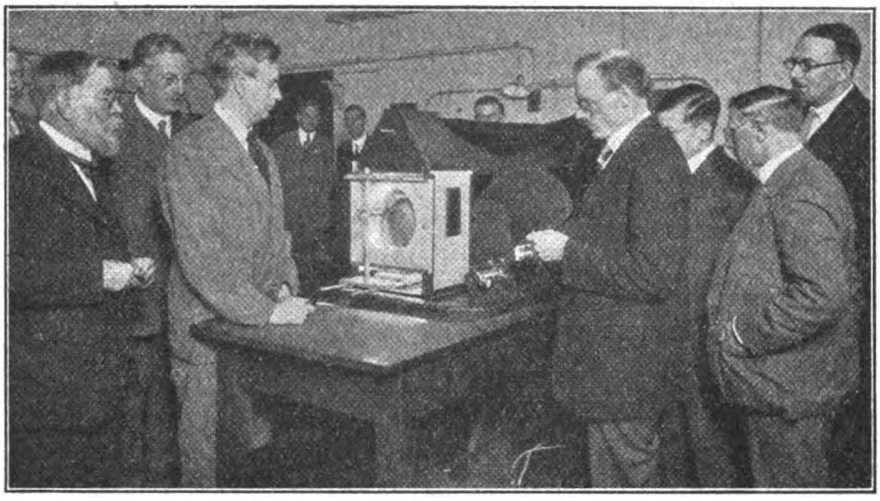
It was in 1926, while Baird was studying light intensities and their photo-electric response, that he investigated and succeeded in utilising the infra-red or invisible rays of light for the transmission of television signals. By this method it was found possible



Mr. Baird explaining his colour television transmitter to members of the British Association at Glasgow in September, 1928.

to dispense with visual illumination altogether and to transmit to great distances a brilliant image of a person seated before the transmitter in total darkness. As is well known, one of the peculiar characteristics of the infra-red rays is their power to penetrate fog, which renders this method of incalculable value to navigation and other essential services where visibility is dangerously obscured by either fog or dense mist. Thus Noctovision, another marvel of universal admiration, was achieved and demonstrated by Baird for the first time in history to Members of the Royal Institution, London, as early as December, 1926.

PHONOVISION is the method evolved by Baird by which the image sound is permanently recorded. By means of these records the original scene can be reproduced repeatedly in the televisor at any time, and the significance and value of this method for the storage and reproduction of the original images of living and other subjects are obvious and as important for vision as is the gramophone record for speech and music.

Of original contributions from other countries to our knowledge of the problems of practical television and their successful solution we find very little that calls for attention.

In 1925 Jenkins in America, using prismatic discs and synchronous motors, fed from a common A.C. supply, succeeded in transmitting and receiving shadows of simple objects. Similar results were achieved in 1926 by Belin and Holweck in France, using oscillating mirrors and A.C. motors synchronised from a common supply.

In 1927 the American Telephone and Telegraph Company gave a spectacular demonstration of television, to accomplish which nearly one thousand engineers were employed. The image was sent by land line from Washington to New York and later by wireless from Whippany, N.J., to New York (30 miles), and much publicity has been given thereto. Dr. M. A. Deauvillier, a distinguished French physicist, writing upon these demonstrations in *Revue Générale de l'Electricité*, Tome XXIII, No. 1, January, 1928, says: "At last the Bell Telephone Company has recently succeeded in transmitting to a great distance by wireless the human face, using (without acknowledgement!) the method of Baird."

In Germany in 1928 Mihaly gave widely advertised demonstrations of the formation of shadows, using what appeared to be an exact copy of one of Baird's earliest experimental models as sold to amateurs by Messrs. Selfridge, Limited. The special correspondent of *Popular Wireless*, August 11th, 1928, reported upon these demonstrations as follows:

"His apparatus is simply the Plotnow or Lipkow—or call it the Selfridge, if you like—disc system. . . . With his discs Von Mihaly showed me names and designs drawn on glass as well as letters. I tried a simple photographic negative, but at the receiving end the detail was hardly perceptible."

Such, then, is the record of facts. In the short space at my disposal I have obviously not attempted to write anything in the nature of a history of television, but rather to review some outstanding facts concerning its origin and progress with special reference to the only practical system at present known. If, therefore, I appear to have dealt at length with the work of any one man it is because to him we are the more indebted for his epoch-making discovery. It is a strange and sinister reflection upon our modern civilisation to find how many a famous inventor, faced with the struggle for existence, finds himself confronted by powerful organisations and vested institutions insidiously using their great influences to oppose and obstruct the progress of an invention in order to acquire or maintain a monopoly upon their own terms.

Equity, it would appear, is the last thing which enters into such considerations. Thus it is that development is impeded for lack of those facilities and support essential to progress. One can only feel glad that we have out-grown the days when such men of genius as Galileo and others were incarcerated for daring to discover and enunciate some fundamental truth. Other days, other methods, but the results are the same. Nevertheless, truth remains.

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How to Make an Accurate Scanning Disc

By *A. R. Knipe*

HAVING made several different types and sizes of scanning discs, it was soon found that absolute accuracy in spacing and drilling the holes was essential, and that something better than marking out by eye and drilling by hand is necessary.

Fig. 1 is a sketch, showing the scanning holes greatly enlarged and projected in one line, of a disc having a circumferential error, that is, the 30 radial lines on the disc are not exactly 12 degrees apart.

The effect on the received picture when using a disc having this error is that any straight lines on the picture have a waving motion or have ragged and serrated edges.

Fig. 2 shows the cause of stationary black and orange bands appearing vertically across the picture;

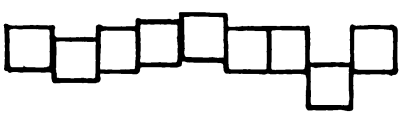

Fig. 1.—Illustrating circumferential error in drilling a disc.

this effect is due to the pitch of the holes being unequal. That is: When the centres of any two holes are *less than their diameter* apart an orange band will be formed, and when the centres of any two holes are *more than their diameter apart* then black bands are produced.

Even if a disc is marked out perfectly either or both of the above errors will inevitably occur in drilling the fine holes. So it was decided to make up a special tool for the job.

After reading the article on scanning discs in this journal* it was decided to make a disc having 30 1 mm. square holes, starting from a radius of 10 inches, the first hole being a quarter of an inch in from the edge; thus the overall diameter of the disc is 20½ inches.

In the first place a sheet of 22 gauge aluminium 21 inches square was procured.

In considering the problem it was soon realised that the jig could be used to serve two purposes:—

(1) For accurately spacing and drilling the holes.

(2) For cutting out a true disc; also it can be used for cutting various sized discs and drilling spirals of different pitch.

The materials required for the jig are as follows:—

(1) 18 inches of ¾ inch by ⅛ inch mild steel strip (this thickness was chosen as it is easily bent cold).

(2) 2½ inches of No. 0 B.A. screwed rod.

(3) One large milled terminal nut, tapped No. 0 B.A.

(4) Two No. 0 B.A. nuts.

(5) One 2 B.A. round or cheese-head screw.

(6) One ½-inch 6 B.A. screw and two 6 B.A. nuts.

(7) A piece of ⅛ inch diameter silver steel 1 inch in length.

Also a short length of spiral spring, $\frac{5}{16}$ inch inside diameter is an advantage though not essential, and was not used in drilling the disc described above.

Constructing the Jig

It will be seen from Fig. 3 that the jig consists of two pieces of steel strip, the short piece sliding on the longer piece and one end of both pieces is bent up at right angles.

Take the 18 inches of steel strip and mark off 1⅛ inch from one end, grip in the vice and bend sharply at right angles; then measure along a distance of 12⅜ inch from the turned up end and cut off.

Next take the remaining piece of strip and mark off 1 inch from one end and bend sharply at right angles as before.

Now place the two pieces together with their turned up ends touching and the smaller strip on top, grip in the vice and drill a ¼ inch hole right through

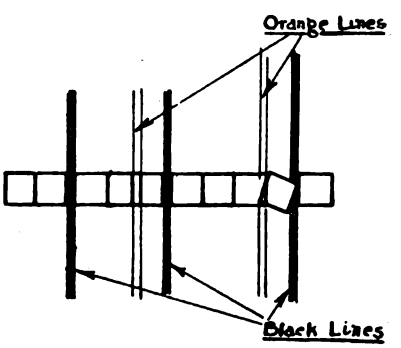

Fig. 2.—When the pitch of the holes is unequal black lines appear between two adjacent holes which underlap, and bright lines between holes which overlap.

* TELEVISION, July, 1929.

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both of the bent up ends, a distance of $\frac{3}{8}$ inch down and in the centre of the strip. This hole is to take the screwed rod.

The short piece of strip may now be cut to length shown in Fig. 3, that is $3\frac{1}{4}$ inches, and a centre punch mark made in the centre of the strip $1\frac{7}{8}$ inches from the unbent end. A $\frac{3}{16}$ inch hole is now drilled through the strip at this punch mark. Next rule two lines on the strip down from the end to the $\frac{3}{16}$ inch hole and remove the metal between the lines by sawing down to the hole, thus making a slot for the 2 B.A. screw to slide in.

Having done this take the piece of screwed rod and run one of the No. 0 B.A. nuts on to one end, pass this end through the $\frac{1}{4}$ inch hole in the short strip and secure with the other No. 0 B.A. nut.

Now take the long piece of strip and drill the holes as shown in Fig. 3, having first scribed a deep line down the centre of both sides of the strip on which the holes are drilled, and to register with the radial lines on the disc when drilling the holes.

The $\frac{1}{8}$ inch hole must be drilled through both the strips; this hole is for gripping the cutter, which is secured by tightening up the milled nut.

It will be seen in Fig. 3 that a slot "B" is cut in this strip, starting $1\frac{1}{4}$ inches from the turned up end and extending along a distance of $1\frac{9}{16}$ inches. This slot can be made by drilling a series of, say, $\frac{3}{16}$ inch holes; it is only to allow the short strip to slide clear of the 6 B.A. centring screw when drilling the disc.

The small hole at the plain end of this strip must be drilled with the same drill that is to be used for the actual holes in the scanning disc, and it should be countersunk as shown.

If desired the piece of spiral spring may be slipped on the screwed rod between the turned up ends.

This completes the construction of the jig.

Cutting out a Scanning Disc

The approximate centre of the sheet of aluminium should be marked and a 6 B.A. clearance hole drilled through the disc at this point.

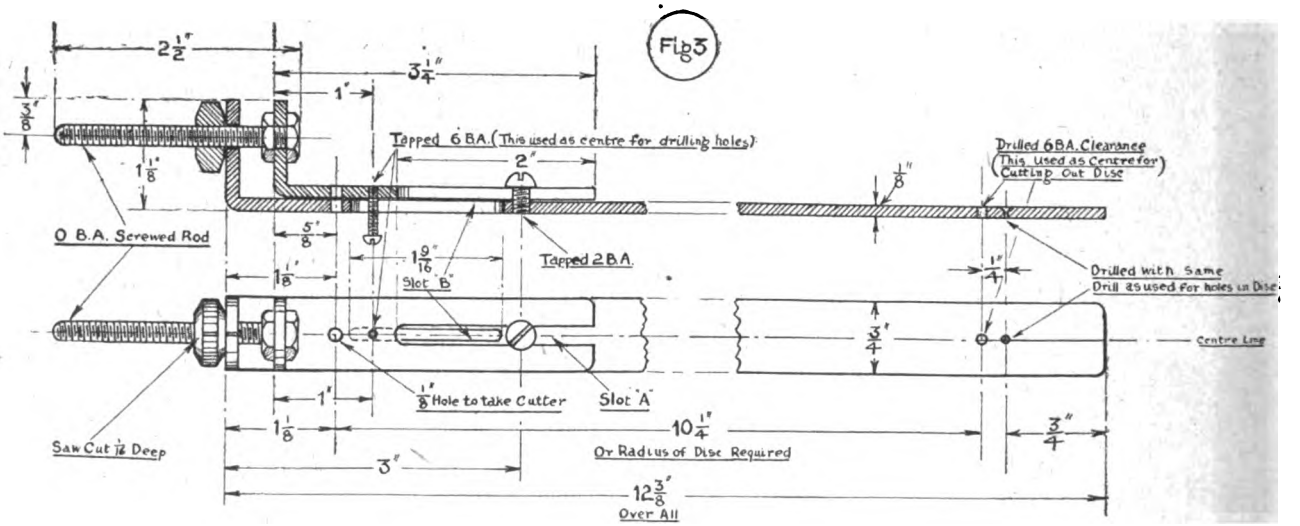
The cutter, Fig. 4, is next inserted in the $\frac{1}{8}$ inch hole in the jig, allowing its cutting edge to project about $\frac{3}{16}$ of an inch; lock the cutter firmly by tightening the milled nut.

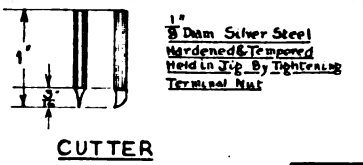
The 6 B.A. screw is now passed through the aluminium sheet and a nut run on. The screw is then passed through the clearance hole in the plain end of the jig and another nut run on and tightened up.

If the sheet is now laid on a flat surface and the jig swung round, pressing firmly on the cutter, it will be found to cut a deep circular groove in the aluminium sheet; after several revolutions of the cutter, the groove will be seen showing through on the reverse side of the sheet.

Now slip the sheet of aluminium off the jig and turn over, and screw the jig on again and rotate the cutter as before. The cutting process may be assisted by lubricating the cutter with a drop of paraffin oil.

Next remove the jig and cutter and by carefully bending the corners of the aluminium sheet to and fro a few times it will crack away and a perfectly true and clean disc will result, entirely free from buckle; the sharp edge may be smoothed with a fine file.





CUTTER

Fig 4

JIG FOR CUTTING & DRILLING SCANNING DISC

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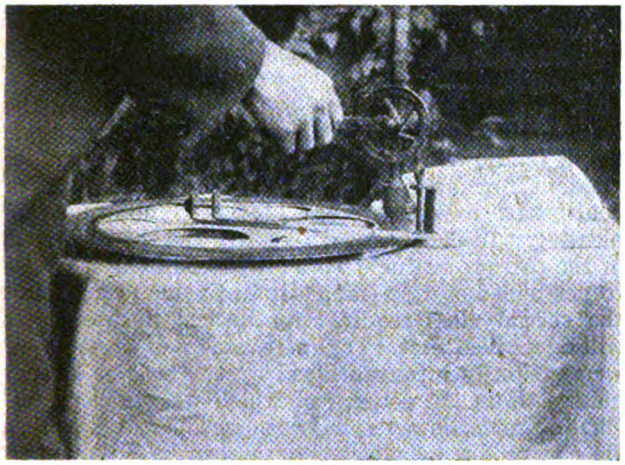
The disc must now be marked with 30 radial lines exactly 12 degrees apart. This may be best accomplished as described in the article already mentioned, that is by using a large protractor.

Drilling the Spiral of Holes in the Disc

Having divided the disc up into 30 equal lines, the 6 B.A. screw is now passed through the centre of the disc, a nut run on, the screw is passed through the slot " B " and screwed through the tapped hole in the short strip and locked by another nut. The milled nut is then run up the rod until the small hole in the plain end of the long strip is about a quarter of an inch from the edge of the disc; next move the jig round until its centre line coincides with one of the radial



Using the jig to drill a scanning disc.

lines. It is held in this position with a small clamp, and the first hole drilled through the disc; the clamp is then removed and the milled nut screwed up *one complete turn*. The jig is moved round to the next radial line, again clamped and the next hole drilled, and so on until all the 30 holes are drilled.

It will now be seen why No. 0 B.A. screwed rod was chosen for the disc described, as No. 0 B.A. thread *is exactly 1 mm. pitch*, and as 1 mm. holes were required each complete turn of the milled nut moves the drilling hole 1 mm. further in each time, thus *tracing out a true spiral* of holes. Of course if $\frac{1}{2}$ mm. holes are required then only half a turn must be given to the nut each time, and if 2 mm. holes are required then, two turns, etc.

To use this jig to drill a disc with a spiral of 1 inch pitch (as described by Mr. A. A. Waters in the December number of TELEVISION), all that is necessary will be to replace the No. 0 B.A. screwed rod by a screw having 30 threads to the inch, but as no standard screwed rod has this thread the difficulty can easily be overcome without having a special screw cut, in the following way.

Replace the No. 0 B.A. screwed rod and terminal nut by a rod and nut of $\frac{1}{4}$ inch Whitworth which has 20 threads per inch and is approximately the same diameter as the No. 0 B.A. rod.

Divide the circumference of the $\frac{1}{4}$ inch Whitworth terminal nut into three equal parts and make three equidistant saw cuts instead of one saw cut as shown in Fig. 3.

Then when drilling the holes instead of giving the nut one complete revolution each time, only rotate it through $\frac{2}{3}$ of one revolution.

Finally the centre hole may be carefully enlarged to suit the driving shaft of the motor.

Squaring the Holes

The holes may be squared by making a punch as previously described in this journal, and to ensure the holes being punched square with the radial lines, I have found it best to drive the punch first through a spare piece of aluminium and then cut this into a strip about $\frac{1}{8}$ inch wide and 1 inch long; then when punching out the holes the strip may be kept on the punch and lined up true with the radial lines on the disc.

Punch the holes through the disc into a block of lead, and do not trouble about the burr, as this is easily and cleanly removed, after all the holes are done, by holding a sharp wood chisel flat on the disc, and gently tapping the chisel; the burr will be found to come away without any tendency to fill up the holes.

The reader will no doubt think of many improvements and additions to this jig, such as mounting a protractor directly on the jig and dividing up the disc and drilling in one operation.

The tool may also be used (by drilling and tapping more holes along the strip) for cutting out smaller circles to lighten the disc.

In conclusion, a disc made with this jig as described has been tested on the morning transmission of television form 2 LO and found to give good definition and freedom from objectionable lines on the received picture, and is well worth the time and trouble of making.

SEEING & HEARING IN THE DARK

When the *Daily Mail* Schoolboys' Exhibition opens at the Horticultural Hall, Westminster, on 31st December, among the many interesting features will be shown for the first time an actual two-way transmission of Noctovision. Young visitors may enter an entirely dark room and will be able to see the movements and hear the speech of their friends in a similar room at the Army & Navy Stores, in Victoria Street, and *vice versa*.

This Noctovision is the result of many years persistent experimental work on the part of Mr. J. L. Baird, the famous television expert, who has been able to transmit moving pictures from England to America by wireless. The opportunity to take part in this wonderful Noctovision transmission is one that is bound to be extremely popular among the visitors to the exhibition, and those who take part in it will regard the occasion, in years to come, as one of no little historical interest.

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Glass

By *W. F. F. Shearcroft*, B.Sc., A.I.C.
Fellow of the Television Society

THE wireless enthusiast, confined in the past to the use of sound as all that his apparatus could produce, had little interest in glass. Television will alter that, as the use of light necessitates the use of glass, which plays an important part in the success of the reproduction.

Glass appears in the ordinary listening-in set only as a protection around the delicate parts of the valves. It does not very much matter what the nature of the glass is, as long as it performs its protective duties.

In the practice of television not only have we to illuminate the subject televised, but we have also to reproduce the original effects, and transmit them to the human eye. In this process, glass will play a prominent part.

A Television Camera

The industry of television will have to face similar problems to those which have been met in the world of cinematography. Further, as we progress and the transmitter is taken out of the studio to deal with the happenings in the open, some light-collecting device will be necessary. The transmitter will become in effect a camera, producing an image, which is converted into electrical impulses, and rebuilt into light effects at the receiving end.

Such a transmission would be utterly ruined unless proper attention were paid to the glass parts of both the collecting and receiving apparatus. We can produce an image, such as we get in a camera, using a cheap magnifying lens, but we know that not only is the image distorted, but that its tones are quite wrong, and it will be fringed with colours due to dispersion. It is common knowledge that the photographer, by using specially prepared glass for his lens, by coupling them with suitable colour screens can produce photographs which are impossible with cheaper material. The photographic problem is slightly different from that of television because the photographer has to produce a chemical effect on his film, which has to be such, that later it gives a natural effect on the human eye, which views the print.

We shall still, however, expect from our television sets fidelity of reproduction, as to perspective and colour, and to some extent this will depend upon that strange substance which we know as glass.

The history of glass stretches back to the dim beginnings of civilizations. It is probable that its discovery was accidental—glass-like masses being found beneath crude cooking vessels. Glass manipulation at a high state of technique is found early in Egyptian history. It is supposed that the manufacture of glass spread from one common centre, so uniform has been its practice over wide areas. The Romans made much use of glass, not only for domestic use, but for personal and architectural decoration, and it has been said that they used it to a greater extent than we do to-day.

The history of glass-making in England, shows the influence of continental practice in its early days, but it is known that English factories could produce glass as fine as that of any of the better known continental towns. Recent history is not quite so pleasing. In the nineteenth century and the beginning of the present century, we allowed continental works to get ahead of us, particularly in the manufacture of the special glass required for optical purposes. It will be recalled that, in the early stages of the war, we were seriously inconvenienced by the lack of optical glasses, from the sources of which we were cut off. That disgrace, however, has been removed, and to-day we can produce glass as good as can be obtained in any part of the world, as a result of the research that English chemists undertook in the matter.

A Complicated Substance

From the chemical point of view glass is a complicated substance, the composition and structure of which is still a matter of debate. Broadly we may state that a glass is a mixture of silicates. The element *silicon* is a non-metal. Its oxide is *silica* (SiO_2), which appears in such common materials as a large proportion of the sand of our sea shore, and also in larger crystals as components of many rock masses. From the oxide of a non-metal there is ideally derived an acid—*silicic acid* in this case, the salts of which are *silicates*. This very simple scheme, however, is rather complicated by the properties of this acid, which is capable of forming most complex derivatives.

The commonest silicate is perhaps the substance known as water glass, which is *sodium silicate*. Glasses are mixtures of such silicates, but the characteristics of a glass are more of a physical nature than a chemical one. We might roughly define a glass as a substance which is hard, and transparent or translucent, and which has passed from a high temperature and fluid state to a lower temperature, without going through any process of crystallisation.

When a molten mass cools the normal course is for a temperature to be reached at which solidification

(*Continued on page* 553.)

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The Prevention of Interference

To Radio Receivers and Amplifiers, due to small Direct Current Motors

By *E. L. Gardiner*, B.Sc.

MOST wireless experimenters will have experienced at some time or other the annoying interference to their reception which is caused by neighbouring electrical machinery, such as trams or trains, electric refrigerators, or lifts. In some districts reception is rendered almost impossible by such causes as these, which create interference in the form of persistent and usually irregular crackling noises. These are generally most aggressive on the longer wave-lengths, but have no definite wave-length of their own, and therefore cannot be effectively tuned out. It is an unfortunate fact that no practicable method is known by which this interference can be eliminated within the receiver itself, and hence the unfortunate listener is forced to put up with it as best he may.

The Worst Offender

Undoubtedly the worst offender in producing interference of this kind is the direct current motor. It is primarily due to the fact that they employ direct current motors that trams, trains, lifts and many other machines cause this trouble. Alternating current motors of the synchronous or induction types do not in general produce any interference, although the small universal type of commutator motor intended for use on A.C. or D.C. is frequently an offender.

Direct current motors are now coming into general use, however, for driving the scanning discs used in television reception. Since these will often be used in close proximity to the television receiving set, and since a rather powerful radio receiver employing considerable low frequency amplification is necessary to give good television results, interference is likely to be caused by the motor, and will have the effect of giving a streaky background to the television image. The writer has experienced this trouble on several occasions while conducting television experiments, and it is thought that a few notes on the methods which have been found most successful in eliminating it would be useful to other experimenters who find themselves in the same position.

In order to understand the reasons for the methods adopted, it is best to consider first why the interference should occur. It is almost certainly due in the first place to the slight commutator sparking which is inseparable from direct current motors, however carefully constructed and maintained. This sparking causes shock excitation of the supply leads and other wiring connected to the motor, the whole acting as a miniature spark transmitter of a very crude nature. High frequency oscillations are set up in the supply leads, which act as quite efficient aerials, and will radiate very flatly tuned signals at about their natural wave-lengths. In the case of a motor running from the public supply mains, all the complicated wiring system of the house will be excited to some extent, and its various circuits may be expected to oscillate at their respective natural frequencies, thus accounting for the apparently untuned nature of the interference, which will be produced on many wave-lengths simultaneously. Naturally, however, the greatest radiation will occur from circuits immediately connected to the interfering motor.

Since commutator sparking is the primary source of the interference, everything should be done to minimise this defect. The surface of the commutator should be kept clean and true, and attention should be paid to the condition of the brushes, which should be renewed whenever undue wear is suspected. This will only serve to minimise the interference, however, and steps must next be taken to reduce it electrically.

Clearly, there are two ways of effecting this. One consists in attacking the interference at its source and trying to prevent high frequency potentials from being set up at the brushes; the second method consists in preventing these potentials from reaching

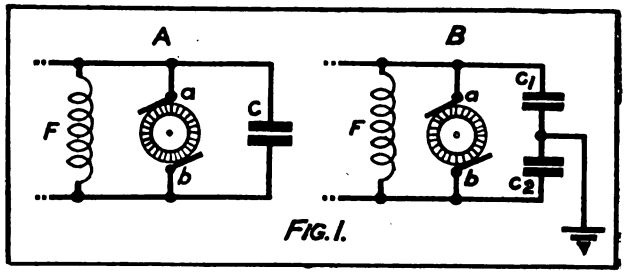

FIG. I.

Simple arrangements, which will eliminate interference to some extent.

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the supply leads or attendant wiring by introducing suitable filters between the motor and leads.

Considering the first of these two methods, Fig. 1 shows the most usual way in which this is attempted. A large condenser C_1 may be connected across the brushes, *a* and *b*, as shown in Fig. 1 (A), to byepass high frequency potentials between these brushes. A better method is to connect a separate condenser to each brush, joining the other terminal of each condenser to earth, as shown in Fig. 1 (B). In each case a shunt wound motor is represented, since this type is of the most general use in television work on account of its steadiness of speed. The connections of the condensers are the same, however, in the case of a series wound motor; and all the circuits subsequently described in this article apply equally to both types.

Condensers not Sufficient

These condensers, C_1 and C_2, are usually made as large as possible, with the idea of providing a very low impedance path to earth for high frequency currents from the brushes. 2 μF or 4 μF represents an average value. In spite of this, however, good results are not always obtained by this method. In many cases little or no reduction of interference occurs, and cases are by no means rare in which the connection of condensers in this way has actually increased the interference to a marked extent. This seems to be particularly the case if condensers of very high quality are employed.

An explanation of this fact suggests itself when we remember that the sudden charge or discharge of a condenser through a low resistance circuit is an oscillatory phenomenon. Probably the series circuit composed of the supply leads and condenser to earth is only slightly damped, and is capable of oscillating very freely when shock excited by a spark at the commutator.

Moreover, consider what will happen if one of the condensers becomes charged due to a momentary break in contact at one of the brushes while passing from one segment of the commutator to the next. The brush will make good contact immediately afterwards, and the charged condenser will discharge through a relatively low resistance path. Such a discharge may be oscillatory, and may also cause a spark at the commutator which will be very effective in setting up high frequency oscillation.

The Real Cause

Consideration along these lines shows that the connection of good condensers as shown in Fig. 1 may reasonably reduce the damping of the oscillatory circuits; and while not necessarily preventing interference, may in some cases actually increase it.

The logical way to prevent the condensers from acting in this manner is to connect resistance in series with each condenser, and in Fig. 2 the circuits already referred to are shown again with suitable resistances added. These resistances can be so chosen that any tendency to oscillatory discharge of the condensers is effectively checked, and the circuits become sufficiently highly damped to render free oscillation almost impossible. At the same time the condensers remain effective in reducing commutator sparking, and in preventing any sudden potential variations of the brushes with respect to earth, or to each other.

The improvement in results which takes place when resistance is added in this way is most striking, and a suitable combination of capacity and resistance connected as in Fig. 2 (B) will invariably effect a most marked reduction in interference. As a guide to the values required, a combination of a 0·5 μF condenser in series with about 14 Ω represents about the best obtainable for motors running on 200- to 250-volt mains. No improvement is likely to be obtained by using larger condensers than this, but experiment may profitably be carried out to determine the best value of resistance to use, as this varies in different cases. In general, a larger condenser and lower value of resistance will be found best for lower voltage motors, and *vice versa*.

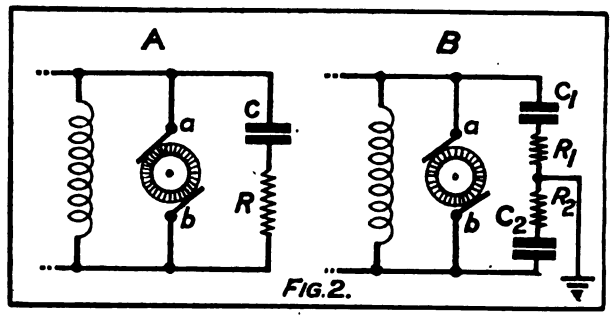

FIG. 2.

A more effective arrangement for preventing interference due to commutator sparking.

Thus 1·0 μF condensers in series with about 8 Ω is a suitable combination for motors running on 100-volt mains. Low voltage motors, running on 6- or 12-volt supplies, do not usually cause so much interference as those running from supply mains; but should they require treatment large condensers of several microfarads should be used, and the best value of series resistance will be low, under 5 Ω. It is quite feasible to use dry electrolytic condensers of 1,000 μF capacity in the case of these very low voltage motors, and these condensers normally have sufficient high frequency resistance in themselves to render external series resistances unnecessary.

Remember, however, that these condensers must be connected with the correct polarity, unlike other condensers in which this point is immaterial.

When fitting up the circuit of Fig. 2 (B), the experimenter should observe the following points if success is to be ensured:—

1. The condensers C_1 and C_2 must be equal in capacity.

2. The resistances R_1 and R_2 must also be equal. Any considerable differences in their values will seriously impair the results obtained.

3. The leads from the condensers to the brushes must be short and direct. If they are long, they may radiate interference, and spoil the results.

4. A good and direct earth is necessary. A long or

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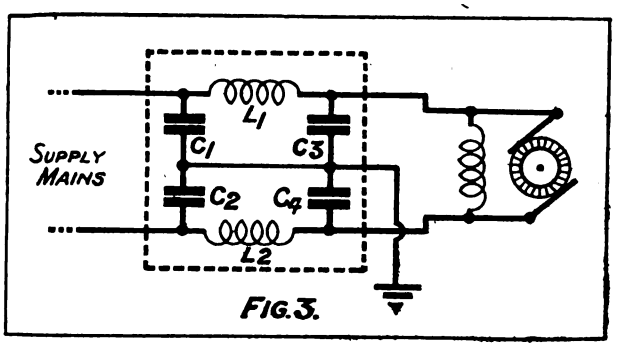

FIG. 3.

The form of filter circuit recommended by the author of this article.

poorly earthed earth-lead may radiate interference to a serious extent.

5. The condensers used must be able to withstand about four times the voltage on which the motor is used. Otherwise they are likely to break down in use. Hence 1,000-volt test condensers should be used on a 250-volt motor to ensure reasonable safety.

Consider now the second method by which the problem of interference elimination can be attacked.

This consists in preventing the high frequency disturbances which occur at the brushes from reaching the supply leads, and can be effected by the introduction of a filter between the motor and its supply, as shown in Fig. 3. No switching or regulating resistances are shown in this diagram, and these should be connected in the circuit externally to the filter. If the motor is a large one requiring the use of a starter or field regulator, these must either be placed close to the motor and connected to it by short leads, or in the event of their being situated at a distance for purposes of remote control, every lead from the motor to its switchgear must contain a high frequency filter, placed as near to the motor as possible. Unless this is done, it is quite useless to go to the trouble of screening the motor itself in an earthed metal case, a refinement which is rarely necessary since very little radiation usually occurs from the motor windings. The frame of the motor may, of course, be earthed with advantage, and it is also helpful to use lead-covered wiring whenever possible, the outer casing being earthed. The chief point to bear in mind, however, is that it is essential to place filters in every long lead connected to the motor, if good results are to be attained.

As a guide to the construction of a filter of the type represented in Fig. 3, all the condensers C_1, C_2, C_3, and C_4 may be of 0·5 μF capacity. The design of a highly efficient choke for use at L_1 and L_2 is a matter of some complexity. The chief factors to bear in mind are the necessity for the highest reasonable inductance, up to about 0·1 Henry, low self-capacity, and the ability to carry the motor current continuously without overheating. This latter consideration tends to make the chokes rather bulky, except in the case of quite small motors. However, quite a satisfactory choke can be made by the experimenter by winding three layers of 20 s.w.g. or 18 s.w.g. D.C.C. copper wire on a piece of paxolin tubing, about 6 inches long and 2 inches in diameter. Pile winding will give the best results, but three layers of wire wound from end to end of the tube will prove satisfactory. A space of half an inch should be left at each end of the tube, to permit of mounting in any desired fashion. This choke will carry a maximum current of approximately 2 amps, and is quite safe for use with mains-driven motors of from 1/40 to 1/4 H.P., such as are likely to be used for television work. It is preferable to mount these chokes in a vertical position, since this facilitates the circulation of air through the chokes, and helps to keep them cool.

At this point the simultaneous use of the two methods of interference reduction already described may naturally suggest itself to the reader. This is quite a practicable proposition, and should be resorted to whenever the interference is sufficiently aggressive to warrant this course. The circuits shown in Figs. 2 (B) and 3 are in no way mutually exclusive, and can always be combined with advantage. When only one method is adopted, however, the second circuit, shown in Fig. 3, will usually give the best results.

For the benefit of those who do not desire to construct filters on the lines described, it may be interesting to note that units incorporating these circuits in a rather more highly evolved form can be obtained in this country from the Dubilier Condenser Co. Certain American firms also construct filters for similar purposes, but I have no precise details of these latter products.

Glass.

(*Concluded from page* 550.)

takes place. During this change of state, heat is given out, but the temperature of the mass does not change. We imagine that some molecular rearrangement is taking place, and normally the molecules build themselves up into solids, with shiny faces and sharp edges, which we call crystals. Some few substances fail to undergo this change while cooling, and the fall of temperature is continuous down to ordinary temperatures. They are in fact over-cooled or super-cooled liquids, so viscous that they appear to us as true solids.

Sand, as a source of silica, sodium or potassium carbonates, red lead or lime are the materials used in the manufacture of the commoner glasses. By the addition or substitution of other components the properties of the final glass may be very much modified. Thus, for example, it is possible to vary the density of glass from about 2·5 to 5. Innumerable experiments have provided the facts, from which it is now possible to calculate the proportions of the components, and so modify them as to produce a glass with almost any required properties as to density, colour, or optical behaviour.

The process consists mainly of mixing the appropriate components and bringing them to a state of fusion in some type of furnace. The temperature reached, and the subsequent treatment have a considerable effect upon the properties of the final product. The molten glass may be blown, pressed or poured into moulds in a semi-plastic condition, after which it is subjected to the process of annealing.

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THE Proceedings OF

The Television Society

Meeting, Tuesday, December 3rd, 1929

LECTURE ON

"Television, Some Suggested Schemes."

By *E. George Lewin*, M.Sc., A.Inst.P.

Fellow of the Television Society.

ABSTRACT OF LECTURE.

The systems discussed include those of :—

RTCHEOULOFF, in which an image of the object is scanned by a photo-electric point on the end of a compound vibrating spring, the image in the receiver being formed by a similarly vibrating fluorescent point.

WHITTEN, in which a scanning mirror is mechanically oscillated by the vibrations of piezo-electric crystals under applied alternating voltages.

VON BRONK, in which a multiplicity of Karolus-Kerr cells are operated to analyse the object and synthesise the image, and the modification in which piezo-electric crystals are made to serve the same purpose.

ZWORYKIN, who uses two prisms rotating at slightly different speeds to effect spiral scanning with an interesting optical system.

MOHR, who analyses mathematically the distortion of the image produced by apertures of finite size in the scanning disc, and inserts filter circuits in the transmitter and receiver to compensate for the distortion.

The December meeting of the Television Society was held at the Engineers' Club, Coventry Street, on December 3rd. It was preceded by an informal discussion on Mr. F. Langford-Smith's lecture on Amplification.

In introducing Mr. Lewin the Chairman, Professor Cheshire, explained that Mr. Priechenfried, who was scheduled to lecture that night, had been called abroad on business, but it was hoped that his lecture was merely postponed.

* * *

THIS evening I am going to talk for a short time about a few of the various methods which have been put forward, at various times, as solutions of the problem of television. I am not suggesting that they *are* all actual and successful solutions of the problem, but they have all been offered, in good faith, as means to the desired end.

Since the 'seventies of last century, down to the present day, the minds of many inventors have been directed towards the achievement of television, and, in the last decade especially, numerous suggestions have been made. However, to anyone considering these suggestions from a practical point of view, it is very obvious that, of the many, only a few could hope to attain any measure of success. Mr. Baird has shown how to surmount the many real and serious

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obstacles which must be overcome before any system of television can hope to merit serious attention from practical men. But there *may* be other ways of surmounting or removing the obstacles to success, and to-night I hope to parade before you some five or six television systems in which different inventors have sought to find other solutions of the problem. None of them, I think, have achieved fame at all comparable with the systems of Baird, Karolus, Mihaly, or Jenkins, but that must not be taken to mean that they can all be dismissed as obsolete and of no account. You must bear in mind that certain of the systems of which I shall speak have only been invented within the last year or two, and the fact that they have not immediately been acclaimed is no real criterion of their ultimate practical value.

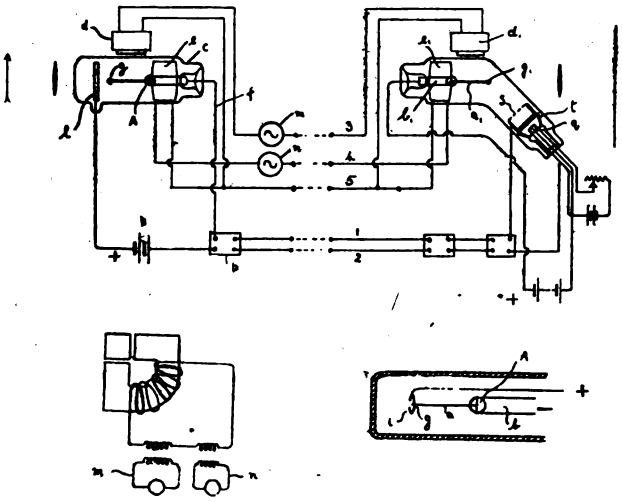

Fig. 1.—Rtcheouloff's system in which photo-electric and fluorescent points g and g, on the ends of electro-magnetically vibrated compound springs, formed of two blades at right-angles and enclosed in evacuated chambers, are provided for the analysis and synthesis of the picture respectively in the transmitter and receiver.

It would be presumptuous of me to attempt to say anything about the Baird system, while those of Mihaly and Karolus are now well known. I have tried to select complete and, so to speak, "self-contained" schemes presenting points of interest different from those of the more famous systems. The main feature of interest is generally the method of scanning, and I have chosen systems representative of the three principal methods of scanning:—by mechanical methods, by methods in which piezo-electric crystals are employed in one form or another, and by optical methods. There is also one interesting system in which the problem of scanning is tackled from a new aspect.

Now, having said so much by way of introduction, may we proceed to the consideration of the first of these suggested schemes.

Rtcheouloff has proposed an interesting arrangement in which both the analysis of the object and the synthesis of the image are performed mechanically. At the transmitter (see Fig. 1) an image of the object is formed by the lens inside the evacuated bulb *C*, so that the plane of the image coincides with the point *g*. *g* is a tiny surface element of photo-electric material (i.e. a substance which emits electrons under the action of light) mounted on the end of a compound spring, shown in detail in the bottom right-hand corner. This spring comprises two blades at right angles, joined in the ball *A*. One blade is much stiffer than the other, and so, if the whole spring is set vibrating, the end point *g* moves over the surface of the image in a series of close inclined lines.

At any point of the image which is bright, the photo-electric point emits a large current, which is collected by the collector ring *L*, amplified, and sent to the receiver, either by wire or wireless. When the point *g* passes over a dark portion of the image, the current is correspondingly small, and the signal is weak. The two parts of the spring are vibrated, each at its natural frequency, by two electro-magnets at right angles, arranged opposite the flat portions of the corresponding spring. The electro magnets are fed with alternating currents of the correct frequency from suitable generators.

An Interesting Receiver

The receiver is specially interesting. It is an evacuated chamber, containing a compound spring exactly similar to that in the transmitter, driven by two electro-magnets fed with alternating currents of the same frequencies as those in the transmitter. The point *g* at the end of the compound spring is now *fluorescent*. In a side chamber is mounted an emissive filament *q*, heated by a separate and constant source of current, and surrounded by a negatively charged reflector *t*. The incoming signal currents, after amplification, are applied to a control grid *S* in front of the filament. The springs are maintained at a fairly high positive potential with respect to the filament, and the energy of the cathode stream impinging on the fluorescent point varies according to the brightness of the original image, due to the control of the grid *S*, causing the intensity of fluorescence to vary accordingly. The motion of the point *g*, which must look like the end of a glowing match, is projected on to a suitable screen to form an image.

As regards synchronism, the main difficulty would be to ensure that the frequencies of the springs in the transmitter and receiver were identical. The inventor suggests a frequency ratio of 100 : 1. The smallness of the photo-electric current, due to the small size of the element *g*, would necessitate considerable and careful amplification, while the illumination of the received image would also be low, unless the fluorescence of *g* were extremely brilliant.

The grain of the picture is limited by the finite size of the photo-electric and fluorescent points. It is possible that there would be a lack of sharpness at the edges of the picture, due to the fact that the image inside the bulb *C* is practically plane, while the end of the spring moves in an approximately spherical surface, though the curvature is very small, and the departure from the plane of the image is only apparent near the edges.

As we have already seen, the main difficulty with this system would be the accurate matching of the

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springs. Further, the elasticity of a spring changes with changes of temperature, and a small temperature difference between transmitter and receiver might make exact synchronism difficult, despite the control of the electro-magnetic drive.

Now let us consider a method in which piezo-electric crystals are used to control the movement of a scanning mirror.

Whitter, in the United States, has designed a system on these lines. Fig. 2 shows the transmitter, but the receiver is similar in principle. It consists of a cabinet containing a fixed vertical surface-silvered mirror and a second mirror, surface-silvered and slightly

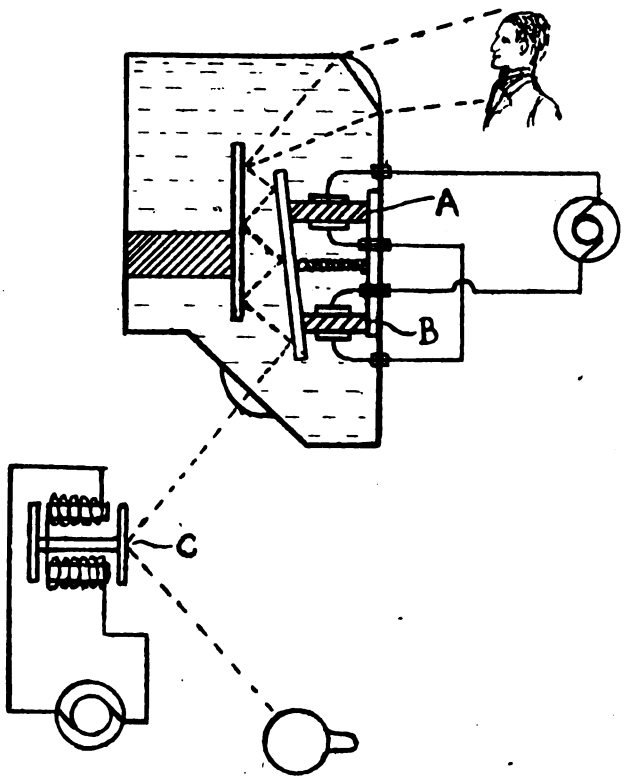

Fig. 2.—Whitter's transmitter, showing the two piezo-electric crystals A and B. These crystals oscillate in opposite phase and actuate the inclined scanning mirror. The other component of the scanning motion is provided by the magnetically vibrated mirror C.

inclined in a vertical plane to the first mirror. This second mirror is supported on a pair of piezo-electric crystals, and held against them by a central control spring. Electrodes are fixed to the crystals and by suitably arranging the scheme of connections with a source of alternating current, one crystal can be made to expand under the influence of the applied voltage, while the other contracts, so oscillating the mirror. The crystals oscillate at their natural frequency, which is arranged to be about 1000 per second. As the movable mirror oscillates it is obvious that the object is scanned from top to bottom. The angular motion caused by the crystals is too small to be effective alone, so multiple reflection (in the case shown, three-fold) is used to amplify the effect of the movement of the mirror. The horizontal component of scanning is provided by the electro-magnetically driven bottom mirror, which is oscillated about 16 cycles per second. The mirrors can be quite small, and the apparatus is not shown in proportion. It is interesting to note that the casing is filled with a mixture of alcohol and glycerine in such proportions as to have a refractive index equal to that of glass. This serves the purpose of damping the oscillations of the mirror.

An apparatus of this type is not immune from the various frailties and failings of all piezo-electric apparatus—occasional unreliability and extreme delicacy of adjustment. It is difficult to make any estimate of the width of the frequency band required for apparatus of this type, but with a scanning frequency of 1000 per second it would probably be pretty wide.

Von Bronk's Scheme

One very ingenious idea on an electro-optical principle has been proposed by Otto Von Bronk, who has been working in this field for a number of years.

You will remember that light which has its vibrations lying all in one plane is said to be "polarized" in that plane. Certain crystals, notably crystals of Iceland spar or calcite, when cut in a particular way and called "Nicol's prisms" will only transmit polarized light when they are oriented in a particular manner with regard to the plane of polarization. Conversely, ordinary light falling on a Nicol prism is polarized by its passage there-through. It has been found that certain substances, and notably two liquids, carbon disulphide and nitro-benzene, possess the property of rotating the plane of polarization of polarized light when the liquids are subjected to an electrical stress. This is the principle of the Karolus modification of the Kerr cell used in photo-telegraphy, in which a small cell of nitro-benzene, containing two electrodes, is mounted between two "crossed" Nicols. Although normally no light would pass through such a cell, as soon as a sufficient electric potential is applied to the electrodes of the cell, stressing the liquid electrically, it rotates the plane of polarization of the light from the first, or "polarizer," Nicol, into such a position that it will pass through the second, or "analyser," Nicol, the light then passing completely through the system as long as the potential on the plates of the cell is maintained. It is, in fact, an electrically controlled light valve, which by proper adjustment can be made extremely sensitive, and extraordinarily lag-free.

Von Bronk s idea is to mount, say, 10,000 such cells in front of the object to be scanned, and then open up one cell after another rapidly, so that the image is scanned from one end to the other. You will notice that the idea is applicable to either spotlight or direct scanning.

The "cells" are layers of a transparent liquid dielectric between the parallel plates of a multiple plate condenser 3 or 4 (Fig. 3), and for simplicity we shall imagine that one of the cells is mounted with its plates vertical and the other with its plates horizontal. These two cells are mounted between a polarizer 2 and analyser 5 at both transmitting and receiving stations. Suppose the polarizer 2 is

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arranged so that the plane of polarization of the light passing through is at, say, 45 degrees to the electric field between the plates of the first cell. Then, in accordance with the laws of optics, it is rotated by a certain amount, say 5 degrees, in its passage through the first cell, and in the same way an additional amount of rotation is provided by the second cell. Now the analyser 5 behind the second cell is so arranged that a certain rotation of the plane of polarization is necessary before any light can get through to actuate the photo cell 7. If the rotation provided by the first and second cells is sufficient, light passes through and excites the photo cell. Note that the rotation is shared between the two cells.

Suppose a voltage sufficient to give the requisite first rotation is applied to the first column of the first cell 3, and at the same time the requisite voltage to complete the rotation is applied much more rapidly to *all* the horizontal layers of the second cell 4 *in sequence*. That is, the point through which light can pass runs rapidly up the first column. If then the voltage is transferred to the second column of the first cell, while the same process is repeated on the second cell, one after another of the cells in the second column open up, and light is transmitted through the photo-electric cell. The cycle is repeated for the third and fourth columns of the first cell, and so on, until the whole picture is completely scanned.

Applying Correct Voltages

The way in which the correct voltages are applied at regular time intervals is shown in Fig. 3, where one pole of the alternator is shown connected to all the alternate plates of the cell, and the other pole is connected to the other alternate plates through chokes and resistances, arranged to introduce a varying lag into the circuits *b*, *c*, *d* and *e*, but no change of voltage, so that the correct voltage is applied to all layers in turn, each one at a definite and regular interval after the preceding one.

The inventor has stated that the use of two cells each containing 100 layers each, giving decomposition of the picture into 10,000 points, is easily possible in practice. The front cell would have to be operated, say, 16 times per second, which means that each of the layers of the front cell would be open for 1/1,600 th of a second, and as each of the 100 layers of the second cell must be traversed in this time, each layer of the second cell would be open for 1/160,000 of a second! Nevertheless, it is stated to be possible in practice.

The receiver is very similar, the two sets of voltages being applied in synchronism, and a variable light source such as a neon tube, or a constant light source controlled by a Karolus cell, taking the place of the photo-electric cell.

But there is a still more interesting modification, the cells of which are also shown in Fig. 3. It depends on the principle first investigated systematically by Cady, who showed that certain crystals, classified as piezo-electric crystals, when excited by H.F. alternating current oscillate at their natural frequencies or harmonics thereof when there is resonance between the frequency of the crystal and the frequency of the exciting current. We have seen how this property

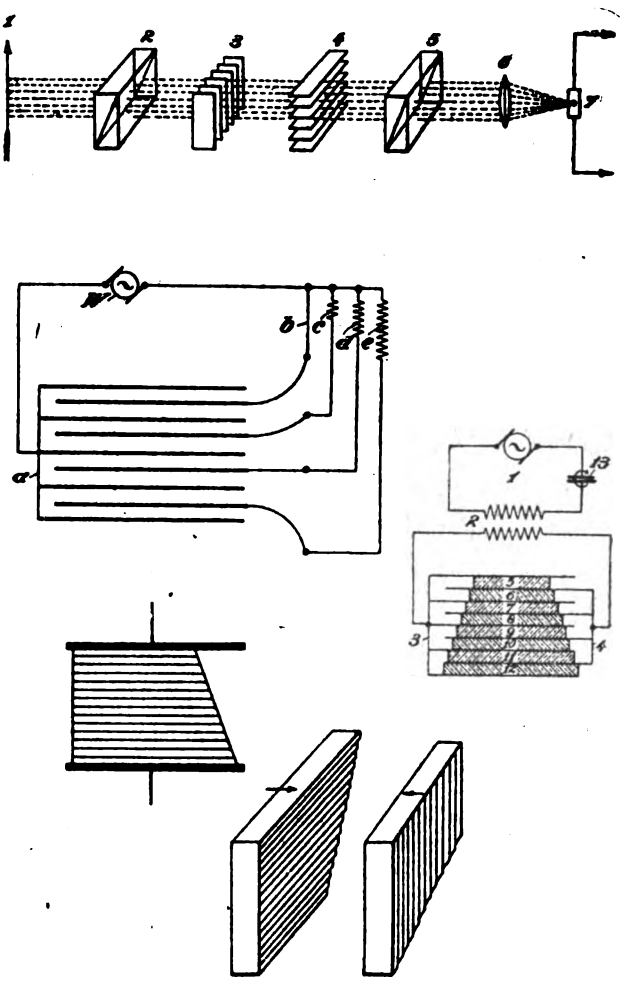

Fig. 3.—Von Bronk's scheme (shown diagrammatically) consists in inserting two multiple-plate Kerr cells, arranged at right angles (3 and 4 Fig. 3) between a polarizer 2 and an analyser 5, and operating the second cell at a multiple of the speed of the first cell, so that vertical scanning is effected by the second cell and horizontal scanning by the first cell. The other modifications are explained in the text.

has been used to oscillate a scanning mirror mechanically, but in the present case a different application of it is made. Quartz is a crystal which exhibits the effect strongly, and crystals thus set in vibration have the property, if arranged properly, of rotating the plane of polarization of a beam of polarized light.

The various layers of liquid dielectic in the original system just described are now replaced by thin laminae of quartz, having different frequencies of oscillation, cut axially and arranged between the plates of the condenser. The whole arrangement is connected to a source of A.C. the frequency of which is continually altered. Only that crystal which is at any time in resonance with the frequency of the alternating current will be set in oscillation, and it is accordingly arranged that each layer resonates in succession. The second control cell comprises a similar arrangement, with the laminae mounted at right angles to the first, and the frequency of the current applied is a suitable multiple of the frequency

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applied to the first set. The two cells are mounted between a polarizer and analyser as before, and light is only transmitted along the line where two oscillating crystals intersect. Scanning of the image is thus performed in the same manner as before. To counteract the effect of rotary optical dispersion of the quartz crystals one set of crystals may be dextro-rotary and the other laevo-rotary.

In a modification, the oscillating crystals are cemented to glass strips so that the glass oscillates at approximately the natural frequency of the crystals, and the light beam actually passes through the glass and not through the quartz. The effect, however, is the same, as the glass strip behaves similarly to a double refracting crystal when it is mechanically strained by the action of the oscillating crystal attached to it.

A quartz crystal 1 cm. long has a natural frequency corresponding to a wave-length of about 1100 metres, and so the first crystal in cell 10 cm. wide has a frequency corresponding to about 11,000 metres; the second strip, which is about 1 mm. longer, has a frequency of a wave-length 110 metres greater, i.e., 11,110 metres, and so on, and the varying oscillation must have a frequency range which embraces all the frequencies, from the lowest to the highest.

It is not actually necessary to use separate electrodes for each crystal, but all the laminae can be clamped between two electrodes (Fig. 3). Von Bronk states that not only can the crystal sections be laid directly on top of one another, but they can be highly compressed without detracting from the optical effect, and this is suggested as a means of damping the whole system to render it lag-free, though the natural damping is very high. Still, for high scanning speeds, any additional sharpening of the resonance region is of importance. This applies equally to the cells at the transmitter or receiver.

Synchronism is obviously a comparatively simple matter with either of the systems which Von Bronk has put forward, as there is no mechanically moving part in the actual scanning system, and the whole of the control is located in the oscillators *W* (Fig. 3) or the continuously varying condensers of the transmitter. When starting a transmission synchronism is automatically picked up by the various liquid or crystal layers in the receiver, without necessitating any preliminary phase adjustment.

As regards practical details, the inventor has stated that it is possible, at any rate in the first modification in which the liquid Kerr cell is used, to construct cells having 100 layers, giving resolution of the picture into 10,000 " points." Even with comparatively wide spacing of the plates in the cell, the grain of the picture can always be made finer by projecting a reduced image with a suitable lens system.

It is interesting to note that the scanning appears to approximate more closely to " dot " scanning than does the linear scanning associated with a spirally perforated disc. Unfortunately the frequency band required for such a large number of " picture-points " as 10,000 is far too wide and impossible to consider under the present conditions. With, say, 30 subdivisions in each cell, corresponding to 900 picture-points on the " dot " theory, and a scanning rate of 12.5 pictures per second, the maximum frequency band required would be 11.5 K.C., while in actual practice the band would probably be smaller, permitting an increase in the number of " points," and consequently finer detail in the picture.

Now let us pass to a method in which the main interest is again the mode of scanning, and which has been invented by Dr. Zworykin, of the Westinghouse Co. of America. You are, no doubt, familiar with the Jenkins prismatic disc, which may be described as a prism curled round the edge of a rotating disc. In Jenkins' method two such prismatic discs are used to deflect a spot of light over the object to be scanned.

Zworykin's System

In Zworykin's system two rotating prisms, rotating at different speeds, are used. The interest lies in the method of mounting the prisms so that the scanning pencil traces out a spiral path. Fig. 4 shows a receiver, but the optical system of the transmitter is almost identical.

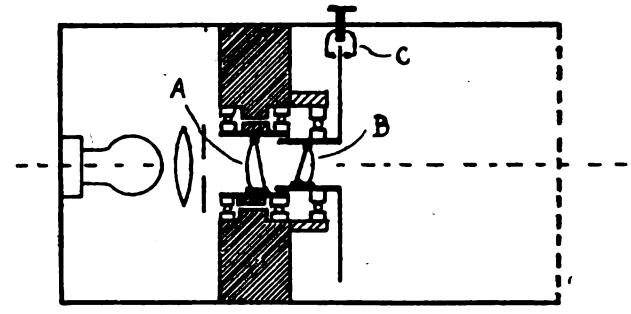

Fig. 4.—A diagrammatic sketch of Zworykin's receiver in which a narrow pencil of light from the neon tube traces out a spiral path through the two prisms A and B, rotating at slightly different speeds. C is the magnetic brake used to control the speed of B.

Light from the neon lamp is colimated (or rendered parallel) by a lens system, and passes through a small hole in a diaphragm to produce a narrow pencil. This pencil of light passes through two prisms, which have convex surfaces ground on them so that no additional lenses are necessary. Both prisms are rotated at high speed, but one more slowly than the other. The first prism is mounted in the rotor of an induction motor, driven from an alternating current source of constant frequency. The second prism is mounted in a steel cylinder, which is quite free to rotate, and is driven round in the same direction by the magnetic drag exerted by the overlapping portion of the rotor carrying the first prism. The speed of the second prism is controlled by the magnetic brake, shown in the top of the picture, so that it runs at a somewhat slower speed.

The pencil of light is bent by the first prism towards its thicker edge, and it is also bent by the second prism towards *its* thicker edge, and the result of the rotation and bending by the two prisms is to cause the beam to trace a close spiral over the object or screen, as the case may be. An important point is that the arrangement produces a crowding of the

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whorls near the outer periphery of the spiral, which tends to offset the loss of apparent luminosity due to the greater linear speed of scanning, but to secure a still more uniform distribution of light a double prism is mounted in the path of the beam as it emerges from the rotating prism, causing super-imposition of the top and bottom parts of the spiral, with a consequent gain in illumination and a more even distribution of light: the inventor even suggests using *six* prisms arranged as shown in Fig. 5, to super-impose six adjacent areas of the spiral.

Six Areas Super-imposed

In the practical embodiment of the scheme the scanning pencil passes first through the two rotating prisms (corrected for chromatic dispersion) and in succession through six lens systems to six specially shaped prisms, giving two internal reflections. The light is received on a screen, where, taking the example of the receiver, the six optical areas are super-imposed.

Synchronism is obtained by adjusting the magnetic brake so that the second prism in the receiver lags at the same rate as in the transmitter. The constancy of such a magnetic brake might be queried, and though I have no personal knowledge of the fact, I should imagine that synchronism is not very easy to obtain or hold.

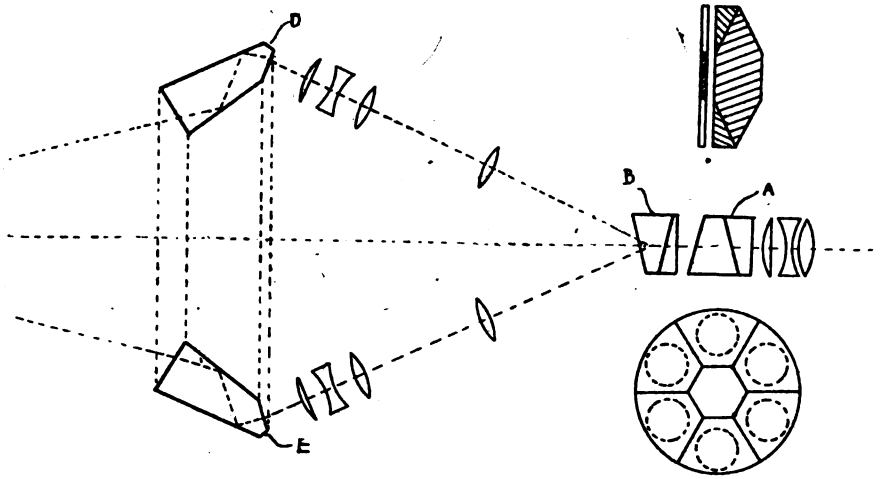

Fig. 5.—Showing a section and elevation of the six-fold prism with which Zworykin super-imposes six parts of the scanning spiral to obtain greater concentration. A and B are the two rotating prisms, while D and E are two of the six special prisms which are also arranged to give six-fold super-imposition of the field.

The calculation of the frequency band required for spiral scanning is not an easy matter, but by making certain approximations it is possible to arrive at a rough estimate. A spiral containing 15 turns (i.e., 30, counting from one side to the other) would need a frequency band of approximately 9 K.C. calculated on the "dot" method. No allowance has been made for the closing of the turns towards the periphery.

The last "suggested scheme" to which I should like to draw your attention is a most interesting one, in that the inventor, first of all, investigated the problem he was out to solve mathematically, and then on the results of his mathematical analysis built up a method complying as far as possible with the various conditions determined by the analysis. The problem Mohr set out to solve was the minimisation of the distortion introduced at both the transmitter and receiver by the use of apertures of finite size in the scanning disc. It is a very old problem, and has already been discussed before this Society in a very able manner by Mr. Owen Harries. It is easy to see how this distortion arises. Suppose we were scanning a black and white chess board with a scanning disc containing fairly large apertures. When the aperture which is scanning the board at any moment coincides with a black square, no light is reflected to the photo-electric cell, and hence no current flows from it. In the same way, when the aperture covers a white square, all the light is reflected to the cell, which gives its maximum current. But what happens in the interval while the aperture is moving from the black square to the white square? At a certain instant it will be scanning the dividing line between the two squares, and so if we could look through the aperture we should see that one-half was dark and the other half was light. This means that only half the maximum amount of light reaches the photo-electric cell, which therefore gives a current equal to half the full current, i.e., the current is proportional to the average brightness of the area scanned.

Now, turning to the receiver, we see that when the black square is being scanned, there is no signal current and the field is dark, while the white square gives the maximum signal current and a maximum brightness in the neon lamp, but the "half-way" signal current causes the neon lamp to glow with a brightness of one half the maximum, and this is distributed over the *whole* aperture in the scanning disc, obviously causing a loss of sharpness and definition in the image, for neither the neon lamp nor the scanning disc can cause all the light to pass through one half of the aperture, as it should do if the image is to be as sharp as the object.

Mohr regards the moving aperture as composed of elementary strips perpendicular to the direction of motion, each of which controls a photo-electric current which represents the brightness of the picture as a function of time. All the elementary strips of the aperture give rise to similar currents, but differing in phase. These currents are generally complex and irregular in form as shown in the bottom curve, Fig. 6; and Mohr, first of all, resolves it into a series of single frequency Fourier components. Choosing a typical component he considers the electrical response for this component due to a single strip of the aperture of very small width, and obtains an expression giving the response in terms of the width of the strip, its distance from the centre of the whole aperture, the position of the point of the picture, and a fourth factor dependent

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on the particular wave component originally chosen. This function is in the form of a wave equation. He then integrates (or adds up) the response for the various strips across the aperture, and finds the amplitude of the whole electrical response of the call is dependent upon a factor of the type $K \sin \frac{\pi}{K}$ where K is a constant determined by the typical Fourier component originally considered.

The first curve shows the variation of this factor $K \sin \frac{\pi}{W}$ for various values of K for the particular case in which the scanning velocity is 8.5 inches per second and the aperture width is 0.015 inches. It will be seen that at certain frequencies (about 550, 1150, and 1700) the response becomes zero—that is, these components are missing from the whole response, and the second curve shows the transmission *loss* variation corresponding to the variation of the response factor. Note that the loss is high at the missing frequencies—i.e., distortion is introduced.

To avoid this loss, Mohr proposed to introduce filter circuits or " equalizers," 8, into the transmitter and receiver which are intended to attenuate certain frequencies of the current to compensate for the distortion introduced by the finite apertures of the disc.

It is a very ingenious suggestion, and certainly goes to the heart of the problem, but it is obvious that its success depends on whether or not filter circuits of the type required in any given case are electrically possible to construct, and how sharply defined their characteristics can be made. Further, with the present limitation of the wave-length band and the consequent limitation of detail, it is doubtful if it is worth while introducing these additional complications. For the present, at any rate, the demand for finer detail could be met by suitably increasing the number of picture strips, provided the restrictions on the available wave-bands were sympathetically reduced.

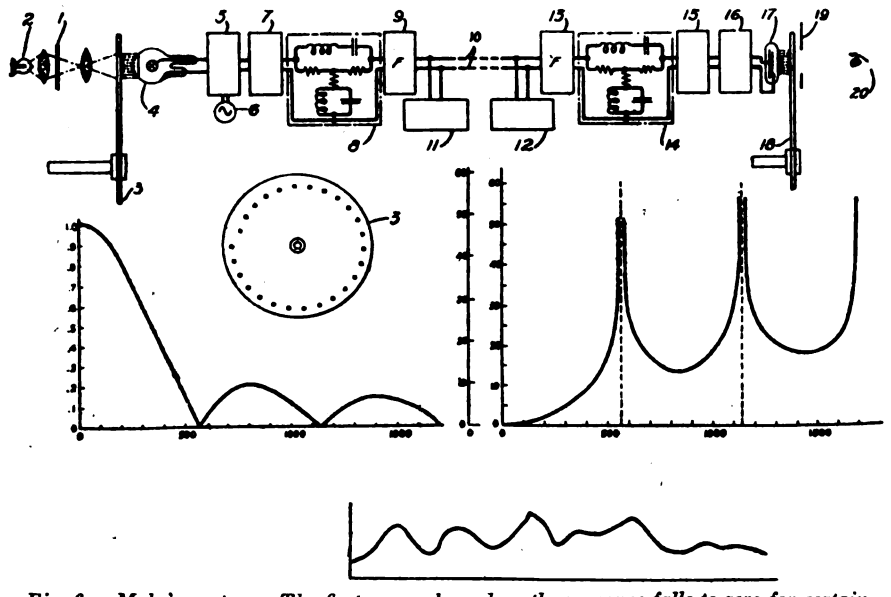

Fig. 6.—Mohr's system. The first curve shows how the response falls to zero for certain conditions of scanning, so introducing distortion, while the second curve represents the corresponding transmission loss. 8 and 14 are circuits with known attenuation constants inserted in the transmitter and receiver to compensate for the distortion.

I have tried to put before you, as succinctly as possible, some of the more interesting television systems other than those about which we hear so much to-day. I am fully conscious that I have been occupied mainly in describing ideas, rather than workable systems which have survived the acid test of successful demonstration. Nevertheless, in television, as in any other Art, it is necessary to have a knowledge of the many before one can have an appreciation of the few. What I have attempted to show you to-night is that there are keen brains at work on the problem of television, and as members of the Television Society we should know something of what they have done. Television opens a new epoch in scientific history, but the *making* of history is given only to the favoured few. Our privilege is to watch that history being made.

Discussion

The Chairman said he had been very struck with the skilful way in which the systems had been selected for treatment so as to give a very broad conception of the subject of television. Those who were interested in it would be able to study the lecture at their leisure when it was published, and he thought Mr. Lewin might in addition give them the references of the English patents dealing with the various systems he had described. That would enable them to consider the various schemes more closely and would, too, provide some further information which was almost essential if they were to understand fully what they had already been told.

Mr. W. C. Keay said he hoped that at a later date the lecturer might visit them again and describe some further systems. He was sure he must have studied the cathode ray question, although he had not mentioned it. This might form the subject of a lecture at a later date.

Mr. Lewin, replying to the questions that had been asked, said he would be only too glad to give the references of the various British patents. At present the main sources of information regarding television had to be the patent literature. Television was such a new subject that the literature on it had scarcely been in existence long enough for it to become systematised and collected. At the moment there was such a large output of it that the only sources to which one could go for information were the British, German and United States patent specifications.

With regard to cathode ray systems, he had deliberately refrained from referring to them, because they had been dealt with very fully a short time ago by Mr. Mitchell. Cathode ray systems for television were not now so popular as they were two or three

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years ago. He did not know the reason for their waning popularity, though they were still very strongly supported in some quarters as the only eventual satisfactory method. With regard to one system there were at least six or seven British patents covering it. A photo-electric screen played an important part in the transmitter, the image being projected on to a plain screen a short distance from it, and then scanned by a beam of cathode rays.

He was not quite sure of the receiver to be employed with this system, but thought it was almost certain to be a fluorescent screen, scanned by cathode rays. The difficulty of all cathode ray systems hinged on the question of light intensity at the receiving end. A very strong supporter of the cathode ray was Campbell-Swinton, who had written a good deal on the subject. Those interested could usefully look up his papers.

A vote of thanks to the lecturer, proposed by Captain D. B. S. Tuke, concluded the meeting.

References to the more important British and American Patents referred to in the Lecture are:—

Rtcheonloff, British Patent No. 287,643.
Whitten, ,, ,, ,, 252,387.
Von Bronk, ,, ,, ,, 277,761.
Von Bronk, U.S. Patent No. 1,670,757.
Zworykin, British Patent No. 290,245.
Zworykin, U.S. Patent No. 1,689,847.
Mohr, British Patent No. 288,237.

SOCIETY NOTES.

The next lecture on Tuesday, January 7th, 1930, at 8 p.m., at the Engineers' Club, will be given by Mr. W. S. Newton, B.Sc., who will speak on "Photographic Problems of Picture Telegraphy."

At 7 p.m., the same evening, Mr. H. Wolfson (Fellow) will contribute a short paper on "Some Properties of Light." If time permits, members will be invited to bring forward matters arising from Mr. Lewin's lecture last month on "Suggested Schemes for Television."

The attention of members is called to the 20th Annual Exhibition, organised by a Joint Committee of the Physical & Optical Societies, which will be held on January 7th, 8th and 9th, at the Imperial College of Science, South Kensington, S.W. We are pleased to be able to announce that our President, Sir Ambrose Fleming, is delivering a public lecture on January 9th, entitled "Television—Present and Future." The Baird Television Development Company has arranged to give demonstrations of television by land line from Long Acre. Mr. R. R. Poole, B.Sc. (Fellow of the Society), is showing his model for demonstrating the principles of mechanical exploring. We feel certain that members of the Society who reside in or near London (and as many others who can possibly do so) will wish to visit the exhibition. A limited number of tickets (gratis) are being made available for the use of members of the Television Society by the courtesy of the Physical & Optical Societies, and early application should be made to the Lecture Secretary at Head Office, who will be pleased to send tickets so far as the supply lasts.

J. J. DENTON, A.M.I.E.E.,
W. G. W. MITCHELL, B.Sc.,
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Motors *and* Discs

By *W. C. Fox*

SINCE the B.B.C. have been broadcasting television many enthusiastic experimenters, taking their courage in both hands, have built receivers. That their results were not quite what they expected is not surprising, for almost without exception they fell into a number of fundamental errors. These notes on motors and discs have been written to answer queries arising from those faults and possibly to help any other workers who may be contemplating the plunge into television.

No apology is made for dealing with discs first, for nearly all amateurs will insist on making them of very heavy and unsuitable materials. It may be a little outside the subject to point out that television is not purely and simply a matter of wireless construction. Mechanics definitely enter into it, and a knowledge of this subject, even though elementary, is a considerable help, as it can save one untold trouble and expense.

The Disc

Given a wireless set, coupled up to a suitable neon tube, one requires a means of preventing the eye from seeing anything but a definite portion of the neon at any given instant. This is most easily and conveniently done by means of a disc pierced with a series of holes arranged in a spiral. The happiest possible state of affairs would be if one could have the holes and nothing else, but as it is a necessary quality of any bung-hole that it should have a barrel around it, so in the case of these holes they must have something—the metal of disc—around them. It is here that a knowledge of mechanics becomes useful.

To alter the speed of movement of any object, force in some form or other is necessary. Also, the heavier the body the greater the force required. Even though the body being considered is a wheel or disc spinning easily about a given centre, this broad and very generally stated law applies.

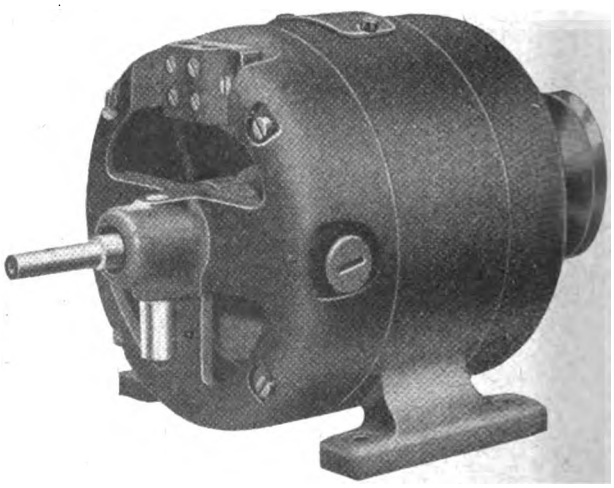
Applied to the television motor and disc, "force" means electrical energy, and the heavier the disc the more energy is required to turn it and keep it turning.

If it was simply a question of paying for the current this would not matter so much, but a heavy disc introduces another and very serious difficulty. The disc is required to turn at one accurate speed, fixed by the speed of the disc at the transmitting station. To keep the disc in the receiver exactly in step one *must* be able to alter its rate of rotation instantly, otherwise the image we are receiving goes out of "frame." A heavy disc requires a lot of pulling up if going too fast, or a lot of force to speed it up if going too slowly, and in any case an *appreciable time* must elapse before it has settled down to the new condition. While this settling down is taking place one has lost the image and has to wait, whereas with a light disc the response is immediate and the settling down period is almost equally short.

For these reasons the lightest possible disc is desirable. If one is using one of the Baird systems of automatic synchronising, the very small amount of power available for controlling the motor speed makes a light disc imperative.

Having decided on a light disc it is no use making it of substances which are normally considered light. Three-ply wood, however thin, is useless, so is $\frac{1}{8}$-inch cardboard. Quite apart from the very considerable weight they represent in discs of 20 inches diameter or so, it is almost impossible to make sharp, clean holes in them. Galvanised iron sheet, $\frac{1}{8}$-inch thick, is another thoroughly unsuitable material, and the labour of cutting it is considerable.

If one is going to use metal, ferrotype plate, which is steel sheet a few thousandths of an inch thick, or aluminium sheet of the same thickness is suitable. Of softer materials, very thin ebonite from $\frac{1}{32}$-inch down to about 10/1000-inch thick, or good stout drawing-paper can be used. The latter is very handy if one wants to experiment with holes and spiral arrangement; ebonite is suitable for a more permanent job. Both of these, although very pliable, will lie out quite flat when rotating at speed. One only



A typical example of the Witton Range of Fractional H.P. Motors manufactured by the G.E.C. to work off D.C. Mains.

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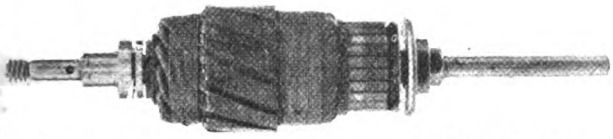
has to be careful to see they do not catch in anything when the motor is started.

Of the two metals, the steel sheet is better, because one can get a cleaner hole in it than with aluminium, and clean, sharp-sided, well-defined holes play quite an important part in giving a good image. Furthermore, their size bears a definite relation to the diameter of the disc.*

While the disc is an important item in the receiver, it is not by any means the only one. The motor driving it demands just as careful consideration.

Broadly, motors can be divided into two groups: alternating current and direct current motors; and ability to control their speed of rotation easily and definitely over a wide range is the standard by which they must be considered.



Armature, showing staggered slots and ball bearings, from a 6-volt Vidal motor.

A.C. motors as a class are not very suitable; some of them can be controlled but not very satisfactorily, while the "squirrel cage" type is definitely not suitable. Any amateur who contemplates using one with gears or friction drives as a means of speed control will be well advised to give up the project and turn his attention to something else.

Of the direct current motors the shunt wound type are best, with a variable resistance in series with the field windings. *Increasing* the resistance increases the speed, and *vice versa*.

Horse Power Required

For average purposes, depending on the size and weight of the disc, from 1/16th to 1/8th horse-power is a suitable size, and if one is to have satisfactory service the motor must be able to run up to 1,000 revolutions, or more. This is higher than the 700 or so revolutions normally required at present, but a reserve of speed is necessary in order to secure a prompt response to synchronising control.

As to current supply, small motors of this type can be run quite well off the mains, or they can be purchased to operate off an accumulator supply of 12 volts or so. The latter is to be preferred by reason of the very steady current assured by this means.

When purchasing a motor every effort should be made to secure one which will run consistently and steadily at whatever speed is desired. Points controlling this are ball-bearings, an armature and commutator of as many sections as possible and staggered armature slots.

In service there must be no sparking at the brushes; otherwise there may be strange streaks and blobs in the received image, for this motor is quite as capable of creating interference in the wireless side of the apparatus as the most atrocious electric sign or badly adjusted industrial motor. It is also helpful to put a fairly large condenser across the brushes and earth the main frame.

Practically any firm specialising in the production of small motors for industrial purposes can supply a suitable instrument.

A Suitable Motor

For the guidance of those who want to know, it may be mentioned that the Vidal Engineering Co., of Thornton Road, Croydon, turn out a series of very suitable motors for operation off accumulators giving 6 or 12 volts, at about 2 to 3 amps. The armature with staggered slots, illustrated, is from one of their 6-volt motors. It has ball-bearings.

The General Electric Company, Ltd., have a good range of fractional horse power motors from 1/40 to ½ h.p., wound to operate in all voltages from 100 to 250 volts. None of them has a maximum speed of less than 1,000 r.p.m., while the smaller sizes go up to 2,000 and over. They are all particularly sturdily built and well up to their work, and although the smaller sizes, up to 1/6 h.p., are without ball-bearings, this is more than made up for by the other features already mentioned.

The importance of having the lightest possible disc, from a power point of view alone, becomes apparent when it is mentioned that a 1/40 h.p., motor costs from £2 15s. to £3 5s. depending on the voltage on which it is to be run. The 1/8 h.p. size costs £5.

Despite these prices, which may seem high, the temptation to use a discarded "fan" motor, or even a good one, should be sternly suppressed unless one is capable of putting it into a thorough state of repair. Even then it is scarcely likely to be of much use except for the roughest of experimental jobs, for it has been designed to turn only a fan where slight variations in speed are of no importance.

W. C. F.

FORTHCOMING LECTURES.

Lectures on television will be given during the month of January at the following places:—

Sir AMBROSE FLEMING, F.R.S., will lecture on "Television—Present and Future," on January 9th, at the Imperial College of Science, South Kensington, S.W.

Mr. A. DINSDALE, A.M.I.R.E., Editor of TELEVISION, has the following engagements:—

Jan. 22nd.—Radio Club, Port Sunlight, Cheshire, at 8 p.m.

Jan. 23rd.—Messrs. Mather and Platt, Ltd., Park Works, Manchester, at 6 p.m.

Mr. J. J. DENTON, A.M.I.E.E., will lecture at the following places:—

Jan. 23rd.—Oxford House, Mile End Road, E.

Jan. 28th.—Highgate Literary Society, N.

*TELEVISION, July, 1929: "Some Notes on Exploring Discs and their Construction."

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Low Frequency Amplifiers for Television

PART I

By *William J. Richardson*

THE question of low-frequency amplifiers for television has been discussed several times in the columns of this journal, but so far exact details of satisfactory circuits, suitable components, etc., generally have been lacking. Obviously, this position will have to be rectified now that we have the definite assurance that early in the New Year advance deliveries of Baird "Televisor" receivers are to be made.

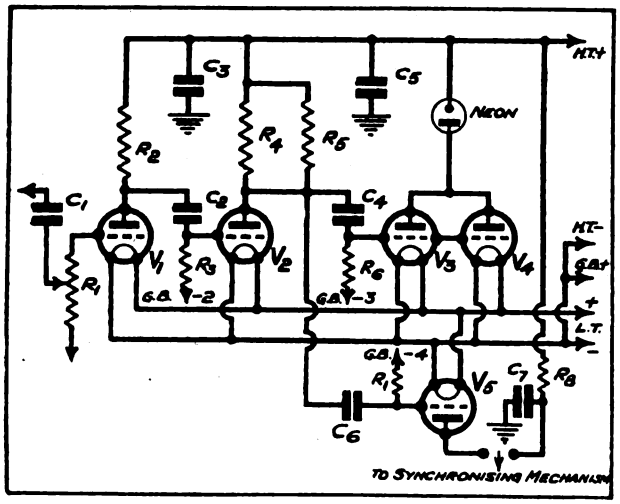

Fig. 1.—A suggested three stage R.C. amplifier incorporating a separate valve for feeding the synchronising mechanism of the Baird "Televisor" receiver.

It is the purpose of the writer, therefore, to make known to readers several alternative amplifier circuits, together with constructional details and component values, so that they can proceed to erect the apparatus for themselves and thus be ready to take full advantage of the benefits that television, as now broadcast daily by the B.B.C., has to offer. It is not suggested that the schemes submitted are the only ones which will function satisfactorily, but they will form a basis for the dealer or amateur to work upon.

A Question of Supply

Provided certain fundamentals are kept clearly in mind, minor points can be settled according to one's inclination, pocket, or the source of supply available to feed both the filaments and plates of the amplifier valves. Obviously, since the amplifier to work after the detector valve and finally feed the neon lamp has to be a power amplifier, then the ordinary small dry cell H.T. batteries are ruled out as unsuitable. If batteries are used for the plate supply, then high capacity ones are essential. Failing that, H.T. accumulators meet the case admirably, provided they are kept in condition, a point which is so often overlooked and accounts for many a bad performance.

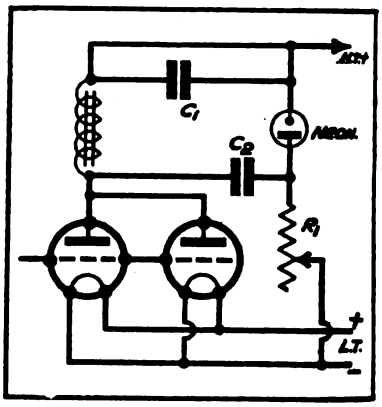

Fig. 2.—Choke feeding the neon is good practice in many cases.

With a source of alternating current available, the problem is met quite simply by pressing into service mains-fed valves either directly or indirectly heated, together with an eliminator of adequate output for the high tension. In addition, of course, valves with filaments fed from accumulators and the plates served by an eliminator are perfectly satisfactory. With D.C. mains it is generally preferable to use a small motor generator or *ML* converter. In the case of anyone with mains, therefore, first cost for the apparatus is practically the only cost, as running expenses are almost negligible.

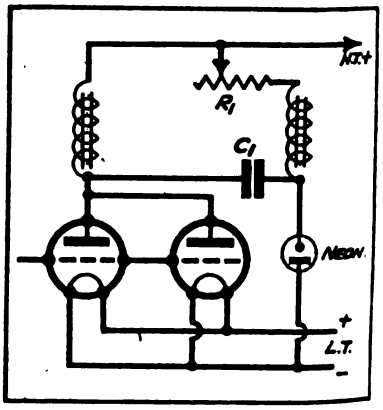

Fig. 3.—Another alternative choke feed neon arrangement.

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A Note in Passing

Just a word as to the detector and high-frequency amplifier (the necessity for the latter being dependent entirely upon the magnitude of the television signal at the receiving station). The best results will be obtained with an anode bend detector, since this type of rectification will stand a very large signal input without distortion, and any form of distortion must be avoided if good pictures are required. In the case of the high-frequency amplifier, do not make the circuits too sharply tuned, otherwise this will cut off the sidebands to the detriment of the picture. However, details referring to this part of the television receiving set have been dealt with by another writer under the heading of "Television and Your Wireless Receiver," both in the October and current issues of TELEVISION, so it will be unnecessary to go over the same ground twice.

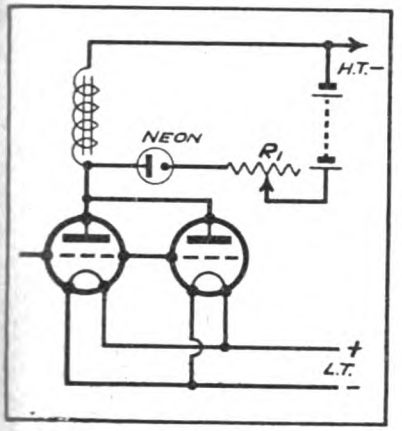

Fig. 4.—If preferred the neon can be connected in the output circuit in this manner.

The Fundamental Function

Now, what is the fundamental function of a low-frequency amplifier, whether for ordinary broadcasting or television? Why, to so handle the input signal that the output signal differs only in magnitude. Every characteristic of the original signal should be

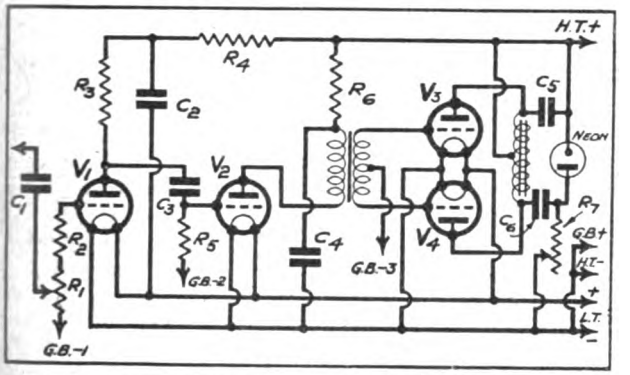

Fig. 5.—An amplifier using push-pull in the last stage has many advantages which may appeal to constructors.

maintained if the best is to be got out of the amplifier, although it is fairly obvious that 100 per cent. efficiency is never obtained in practice. Always aim high in your endeavours, however, otherwise you are liable to reach only a mediocre standard.

Since this article is mainly introductory in character and penned with the object of stimulating interest in the low-frequency side of the subject, only a brief reference to the six circuits will be made, a more detailed explanation with component values being furnished next month. With the signals as now sent out from the B.B.C. station, a positive picture is obtained with an anode bend detector followed by three stages of resistance capacity coupling. By a positive picture is meant a picture with the true light and shade relationships, for whereas in ordinary sound broadcasting the current direction in the output valve makes no difference to the actual sound heard from the loudspeaker, in television it does. A plate current increase heightens the neon glow, whereas a decrease lessens it, so that if these effects should be reversed the result will be a picture dark in the high lights and light in the dark areas.

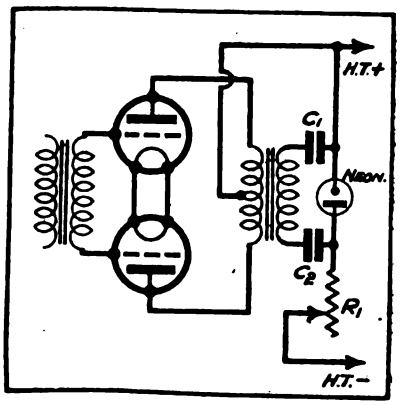

Fig. 6.—For the output stage of the Fig. 5 circuit a transformer may be used if desired.

Changing a Negative

That is, it resembles a photographic plate instead of being like the print taken from it. It is not always realised that plate current reversals take place in the inter low-frequency coupling stages, and to rectify matters if a negative picture is obtained it is necessary either to add or subtract an R.C. stage in the amplifier or reverse the primary or secondary connections to the transformer if one should be present. Of course, the same reversal effect can be produced by changing from anode bend to grid leak detection, but generally this is not recommended for the reason enunciated earlier.

The first criterion, therefore, with the television L.F. amplifier is to have the correct number of stages, otherwise make provision for a simple change so that a correction can be made if a negative picture is secured on the screen.

Examining the Circuits

In Fig. 1, then, we have three resistance capacity stages with the last two valves in parallel. All these valves are of the LS5 class. There is one feature that calls for special comment and that is the provision of a separate valve to amplify and control the synchronising impulses which, as we all know, in the Baird system are an integral part of the picture signal itself and do not require a separate transmission channel. The synchronising will be effected through the cogwheel synchroniser since this method has now superseded the older relay type of mechanism.

This feature of a separate valve for synchronising

(*Continued on page* 569.)

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The Nature and Properties of Light

PART II.

By *H. Wolfson*

LAST month we discussed the evidence in favour of the various theories of light, and also pointed out the failings of these theories. We were forced to conclude, from the evidence at our disposal, that the theory which most nearly fulfilled our requirements was the *Wave Theory of Light.*

In the present article we shall discuss vibrations and waves, and methods for determining their velocity and wavelength. It is hoped that this article will be the means of clearing up any difficulties which may exist with regard to these problems in connection with the subject of light.

In the study of periodic motion, such as we are familiar with in the form of pendulum vibrations and the like, we come across a special type which demands rather closer attention. This is the so-called Simple Harmonic Motion. Here we say that if a force which is acting on a body is proportional to the distance of the body from the equilibrium position, then the body is executing simple harmonic motion.

Consider carefully the first diagram (Fig. 1). Here we have a point *P*, tracing out a circular path, by revolving with a uniform velocity about *O* as centre, the direction of motion being anti-clockwise. Construct the *base line CD* by continuing the diameter *AB* of the circle. Now imagine that we treat the point *P* at a number of various positions, separated by a definite angle, say 30 degrees. This gives us twelve different positions to consider. Through each point draw a line parallel to the *base line*. Divide the distance *CD* into twelve equal portions, to correspond to the twelve positions of *P*.

When *P* is on the base line, at the point *B* let us mark the point (1) and as *P* moves round the circle, in the direction of the arrow, we can, at each of the twelve points on the circle, find twelve corresponding points, at various heights above the base line, as shown. On joining these points by a smooth curve we obtain the graph of simple harmonic motion, which we term a *sine curve*. The maximum displacement (4) is equal to the radius of the circular path of *P*, and is termed the *amplitude*. Similarly, the *phase* of the S.H.M. at any instant is equal to the angle swept out by the line *OP* measured from the base line, or time axis.

It is useful to remember that we can define the position of *P* in two ways. Either we can refer to the angle which it has swept out, or to the fraction of time for which it has been moving. Then we can state that the time taken to pass once around its circular path, or to trace out the first 360° of the sine curve, is the period of the S.H.M. The wavelength of the motion is found by measuring the distance *CD* between the beginning and end of one complete vibration. The frequency of the vibration is found by counting the number of complete vibrations along

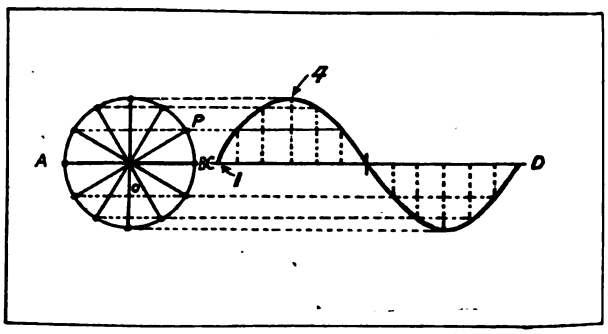

Fig. 1.—A pure sine curve, illustrating S.H.M.

the time axis (base line) which occupy *the space of one second.*

The velocity of the particle *P* can be calculated by assuming the radius of the circle traced out to be *r*, and the time required to go once round is *T*, the period. Then, by elementary geometry, the length of the circular path is $2\pi r$, the circumference of the circle. The velocity is found by dividing distance travelled by time required to travel the distance, i.e., velocity is equal to $2\pi r/T$.

So far we have been studying *free* vibrations, but there is another important class of vibrations which are produced under the action of a *periodically varying* force. In this case the body is forced to vibrate with the same period as the inducing force, and its vibrations are consequently termed " forced."

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Having thus indulged in a preamble, we are in a position to study wave motion. We use this term in connection with a motion of the following type. Imagine a number of bodies united by means of elastic connectors. It is impossible for one to move without disturbing the others, and a disturbance or displacement of any one will cause a greater or less displacement of the others. If the first is caused to execute some periodic motion, then all the others will be constrained to follow its example, and to vibrate with the same period. It must be observed that a particle does not move continuously in one direction but oscillates about a fixed mean position of equilibrium. In a given medium, the disturbance which is set up will be transmitted with a definite velocity. Whenever we set a particle in motion it will acquire kinetic energy, and this energy will be communicated to the next particle, and so on, since energy cannot be created or destroyed. We find, therefore, that all wave motion is accompanied by the transmission of energy.

We can imitate wave motion experimentally by the use of a flexible cord, stretched between two points, or attached to a support at one end while the other end is held in the hand. If an up-and-down motion is transmitted from the hand to the cord, a succession of waves will be seen to pass along the cord. If the velocity of the up-and-down motion is constant, the wavelength will be constant, and can be measured. A succession of waves such as we obtain in this instance is called a *wave train.*

Path of Wave Train

As a wave train passes any particular point, the latter executes a S.H.M. which is similar in every respect to that of the point at the beginning of the train which in this case is the end of the cord which is held in the hand. Particles in the path of a wave train simultaneously moving in the same direction through positions of equal and similar displacement are said to be in the same phase. The distance between any two neighbouring particles which are in phase is termed the wavelength of the train.

Two terms which are much used in connection with wave motion are the *crest* and the *trough* of a wave. These two terms are self-explanatory. The distance between any two crests or troughs is either one wavelength or a whole multiple of one wavelength. We have already considered the amplitude of the wave, which is the distance from the time axis to a crest or a trough, which corresponds to the maximum displacement of the particle.

The wavelength is usually represented by the Greek letter λ, and can be connected with the period and the velocity of the wave by the equation

$$\lambda = VT \ldots\ldots\ldots (I).$$

But the *period* is the time of one vibration only. We know that by definition (*vide infra*) the frequency is the number of vibrations or complete waves executed in one second. It is a matter of arithmetic then to show that the frequency ν is equal to the reciprocal of the period, that is, to $1/T$. In other words, T is equal to $1/\nu$. Substitute in equation (*I*) above, and we obtain the well-known result that

$$\lambda = \frac{V}{\nu} \ldots\ldots\ldots (II).$$

This equation holds good for any form of wave motion, whether transverse, as hitherto considered, or longitudinal, as in the case of sound waves.

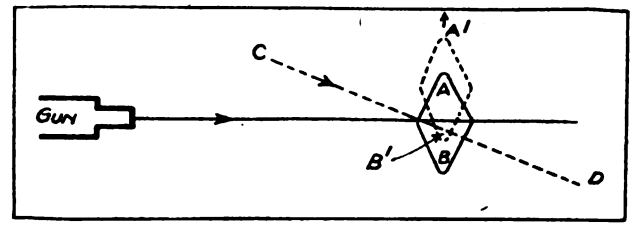

Fig. 2.—Explanation of the aberration of light by means of the ship analogy.

This equation seems to have given rise to a number of misconceptions. Equation (*I*) gives the length of the wave as a function of V, the velocity of the wave, and of T the period. λ varies with the medium in which the wave is propagated, for the velocity of the wave is different according to the medium. The frequency, or number of periods per second, is a constant characteristic of a monochromatic electromagnetic wave; whatever medium is being traversed it remains the same.

Let us imagine a monochromatic beam of light passed through a block of glass, which is a denser medium, optically, than air. The velocity is lowered, and since the frequency is unalterable, for a wave of the particular colour in question, the wavelength of the radiation *while in the glass*, will be lowered. As soon as the ray emerges into the air at the other side of the glass it will regain its old velocity, its old wavelength, and, consequently, will not have suffered any *permanent* change as a result of its passage through the denser medium.

If we consider the matter from a different angle, suppose that we keep the velocity constant, that is, we allow the wave to pass through a medium of uniform density. Suppose, now, we are able in some way to change the frequency of the light. Then, follows from the equation that we must also change the wavelength. A rise in frequency gives a shorter wavelength, and *vice versa.*

Constant reference has been made to the velocity of light, and a number of my readers would no doubt be interested to learn how physicists have endeavoured to measure this quantity with the accuracy which is required of such an important fundamental physical constant.

One of the earliest methods was an astronomical one, devised by Römer. Observations of Jupiter's satellites show that while the earth in its orbital motion is receding from Jupiter, the average period between successive eclipses of a certain satellite is longer than when the earth is *approaching* Jupiter. Römer explained this by supposing that when the earth is moving away from Jupiter the light from the satellite has to travel further at each disappearance.

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By means of a calculation, with which we need not trouble here, he was able to find a value for the velocity of light, which was extremely good, the value obtained being approximately 187,000 miles per second. This is the same as 301,000,000 metres per second.

The next method, due to Bradley, depends upon the phenomenon known as the aberration of light. This method is usually explained as follows. Imagine a ship, AB, Fig. 2. Suppose that a shot is fired from a gun into the ship, in a direction at right angles to the ship. If the ship is not moving, the shot will go straight through, and will leave at a point the same distance behind the bow as the point at which it entered. On the other hand, if the ship has moved to a position A^1B^1 when the shot leaves the other side, then the shot leaves at a distance b, from the bow, whereas it entered at a distance a from the bow. The distance b is greater than the distance a. To an observer it will appear as if the shot has travelled in a direction CD, which is an imaginary line joining the two holes.

If the velocity of the ship is v, and that of the shot V, and let the time taken for the shot to pass through the ship be t. Then $b-a=vt$. Also the distance travelled by the shot parallel to the direction of its absolute motion will be Vt. We can express the angle θ between the two paths, real and apparent, as tan $\theta=vt/Vt$, or as v/V. The analogous case is that of light reaching us from a star, the apparent direction of the light being affected by the earth's motion. If v be the velocity of the earth, and V that of the light from the s star, the angle between the true and apparent directions of the light will be as above, θ, where tan $\theta=v/V$.

Observation of a particular star near the zenith of the spring and autumn equinoxes will reveal a

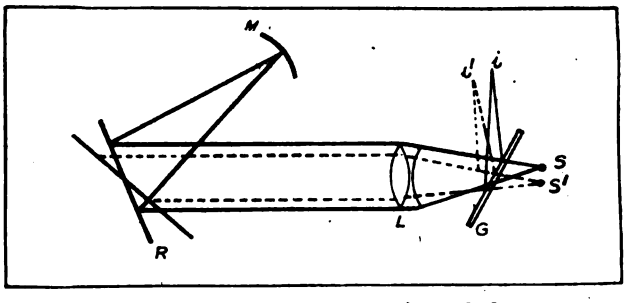

Fig. 3.—Fizeau and Foucault's method.

difference in position, due to aberration, and tan θ will be equal to v/V and $-v/V$, at the spring and autumn equinoxes respectively. The orbital velocity of the earth being already well known, it is possible to calculate the velocity of light if the angle θ is measured. The value obtained in this way by Bradley was 308,300,000 metres per second. This value, though of the right order of magnitude, was not so near to the true figure as the one obtained from astronomical data by Römer.

The first measurements, which were independent of astronomical observations, were carried out by Fizeau. He sent out a beam of light from an aperture which was opened and shut many times per second. These flashes were reflected back to the point of origin after travelling a considerable distance. If the various factors are properly timed each flash will find the aperture closed on its return. The velocity of light is very great, and it is therefore necessary to use accurate mechanical means to open and close the shutter. The shutter employed consisted of a toothed wheel, the speed of which could be varied at will. The distance between the source and the concave reflector was about 4 miles.

Matters were so arranged that light which left between two teeth was intercepted on its return journey by the next tooth. This tooth had moved a distance equal to half the distance between two teeth in the time taken for light to travel from the source to the reflector and back again. On increasing the speed of the wheel, returning light passed through the next opening, and at still greater speed was again intercepted, this time by the next tooth but one, which had moved a distance equal to one and a half times the distance between two teeth.

Fizeau's Experiments

Thus, if the speed of the wheel is known, we shall know the *time* required for a tooth to move the aforementioned distance (either half or one and a half times the distance between two teeth). In this time the light has travelled to the reflector and back a distance which can be measured in the ordinary way. Hence the velocity of light can be calculated. Fizeau's value was 315,000,000 metres per second.

By automatically recording the speed of the wheel and making other slight alterations in the method of taking observations, M. Cornu was able to obtain an improved value of 300,100,000 metres per second. Other improvements on the method were made by Young and Forbes, whose value agreed very well with that of Cornu.

By 1850, further advances had been made by Fizeau and Foucault, working independently, with almost identical apparatus. Use is made of the rotating mirror principle, which finds a wide application in physical problems. Light from the slit S, Fig. 3, was focused by a lens L on a concave mirror M, after being reflected at the plane mirror R. The centre of curvature of M was at the centre of R. The mirror R can be rotated about an axis at right angles to the plane of the diagram. So long as any light falls on M, the central ray will always be reflected at normal incidence.

Thus the incident and reflected pencils of light will coincide exactly, so that the returning light will be brought to a focus at S. Let us interpose a plane sheet of glass G as shown, so that part of the returning light is reflected, and forms an image at i. If R is rotated slowly, i will disappear when light ceases to fall on the concave mirror M, otherwise the image i will be perfectly stationary. On increasing the speed of rotation of R, since light takes a certain time to get from R to M and back, in the intervals between successive reflections from R the latter will have rotated through a definite angle. The path of

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the returning light will thus be different from that of the incident light, and this is shown in the diagram in dotted lines. A new image will be formed at S^1 and i^1. The distance ii^1 gives the angle through which the mirror has rotated. We know the velocity of the mirror, and thus we know also the time taken to rotate through the angle corresponding to ii^1. *In this time light has travelled a distance of twice RM.* The velocity of light can thus be calculated. The distance *RM* is made about 20 metres, and the distance ii^1 is about 0·7 mm. The value obtained from this type of experiment was 298,000,000 metres per second. This is actually somewhat lower than the figure which we accept at the present time.

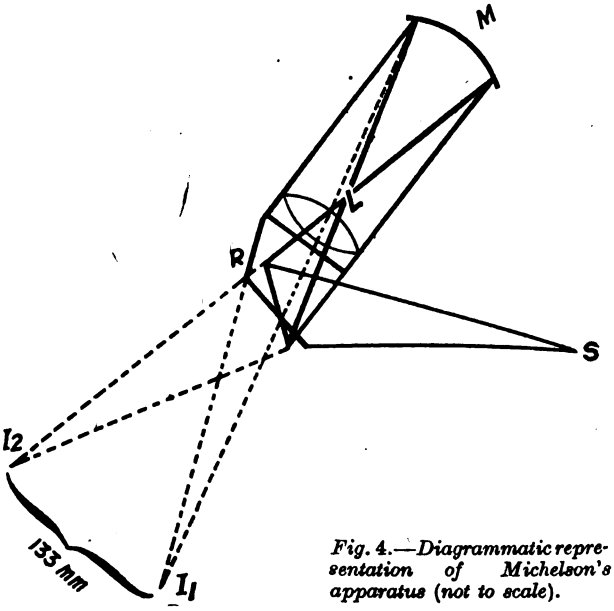

Fig. 4.—Diagrammatic representation of Michelson's apparatus (not to scale).

The last method which I shall describe is that due to Professor Michelson, of America, whose name is famous in connection with his experiments on the velocity of light, the measurement of ether drift, etc. He modified Fizeau and Foucault's method so that the distance *RM* was 600 metres, and the resulting distance between i and i^1 became 133 mm.

Further, instead of placing the lens between *S* and *R*, he transferred it to a position between *R* and *M*. This results in a brightening of the final image, which becomes thereby practically independent of the great distance between *R* and *M*.

The source of light in these experiments was sunlight, which had to pass through a narrow slit *S*, Fig. 4. The lens between *R* and *M*, indicated at L, had a focal length of something of the order of 150 feet. The distance *RL* being 135 feet, *SR* being 30 feet, and *LM*, 1,850 feet.

The centre of curvature of the concave mirror is at the centre of curvature of the lens *L*. In this case the final image will be an exact reproduction of the slit. The necessary radius of curvature is very great, 1,865 feet in fact, and this means that the mirror is very nearly plane. This introduces enormous difficulties, as it is almost impossible to shape correctly a concave mirror of this curvature. Michelson was therefore forced to employ a good plane mirror, which resulted in the loss of definition in the image. The great deflection of the final image was, however, more than sufficient compensation for this.

The rotating mirror was driven by an air turbine at a rate of 256 revolutions per second, and this was checked very accurately by an ingenious type of stroboscope. A beam of light was thrown on to the motor, and reflected from it by means of a mirror on to a small mirror carried on the prongs of an electrically driven tuning fork, whence it was finally reflected into a telescope. The frequency of vibration of the fork was 256 per second, so that when the motor was performing the correct number of revolutions, it seemed as if the spot of light, as observed in the telescope, was stationary.

In this way Michelson succeeded in obtaining values ranging from 299,793,000 metres per second and 299,913,000 metres per second. For all practical purposes we can assume with safety that the velocity of light, and, for that matter, of all electro-magnetic radiation, is three hundred million metres per second.

Low Frequency Amplifiers for Television

(*Concluded from page 565*)

is, of course, optional, for the system works almost as effectively when the synchronising coils are in series with the neon in the output circuit of the last valve or valves.

Since the neon must have a definite voltage across its electrodes before it will strike, it is frequently an advantage to choke-feed the neon so that the overall amplifier voltage may be reduced. Figs. 2, 3 and 4 give three possible connections whereby this may be put into practice, and on the whole there is little to choose between any of them.

Coming to Fig. 5, this is another suggested three-stage amplifier with the last two valves in push-pull and the neon choke fed. Stabilising resistances and condensers (or anti-motor-boaters, as they are popularly termed) are also included. One advantage of this type of amplifier is the reduction in the overall H.T. voltage, which, as readers will know, is perhaps the main feature characterising push-pull amplifiers. In Fig. 6 I have shown an alternative method for joining up the neon, a centre tapped output transformer being used instead of the centre tapped choke of Fig. 5.

It is hoped that these suggestions will encourage readers to make a start for themselves in building a "pukka" amplifier for their television reception. In any case, experiments are being conducted by the writer and it is hoped to give detailed information next month, together with lists of components and satisfactory baseboard layouts. It is left to the individual tastes of the reader as to whether he builds his set complete with amplifier in one whole unit or constructs the amplifier separate and couples this externally to his detector valve. Each has its own advantages, but I am inclined to favour the latter policy, at least for a start. Once satisfied as to his results, the amateur can then build up the receiver in one cabinet.

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Experimental Television Apparatus

By *A. A. Waters*

PART VIII

IT will be interesting to know the experiences of the readers of these articles who have followed the directions given in the preceding article of this series. It was suggested by the Editor that a series of reports would be welcomed, and, personally, I should be pleased to see reports published.

Before proceeding with a description of the synchroniser and its construction it will be well to emphasise the importance of accuracy in the construction of receiving discs, which to give pleasing results should be made with the aid of precision instruments. Scarring lines on the received image are entirely due to the holes being slightly out of place. These lines are bright where the consecutive holes are too close diametrically, and black where they are too distant. A perfectly illuminated image is only possible with a precision-made disc. Naturally, too, the scarring of the image is a result to be avoided, so too much importance cannot be attached to this part of the receiver. With regard to the synchronising device, too, the better the workmanship the better the results.

Methods of Construction

The first method of construction adopted required the use of a lathe for practically the whole of the work, and the following instructions are intended for those who have the necessary skill and convenience for carrying them out.

The motor is the same as used in all our experiments, that is, 1/40 h.p. G.E.C. Universal, as it has a spindle that projects at both ends from the outer casing. One end is used to mount the receiving disc, the other

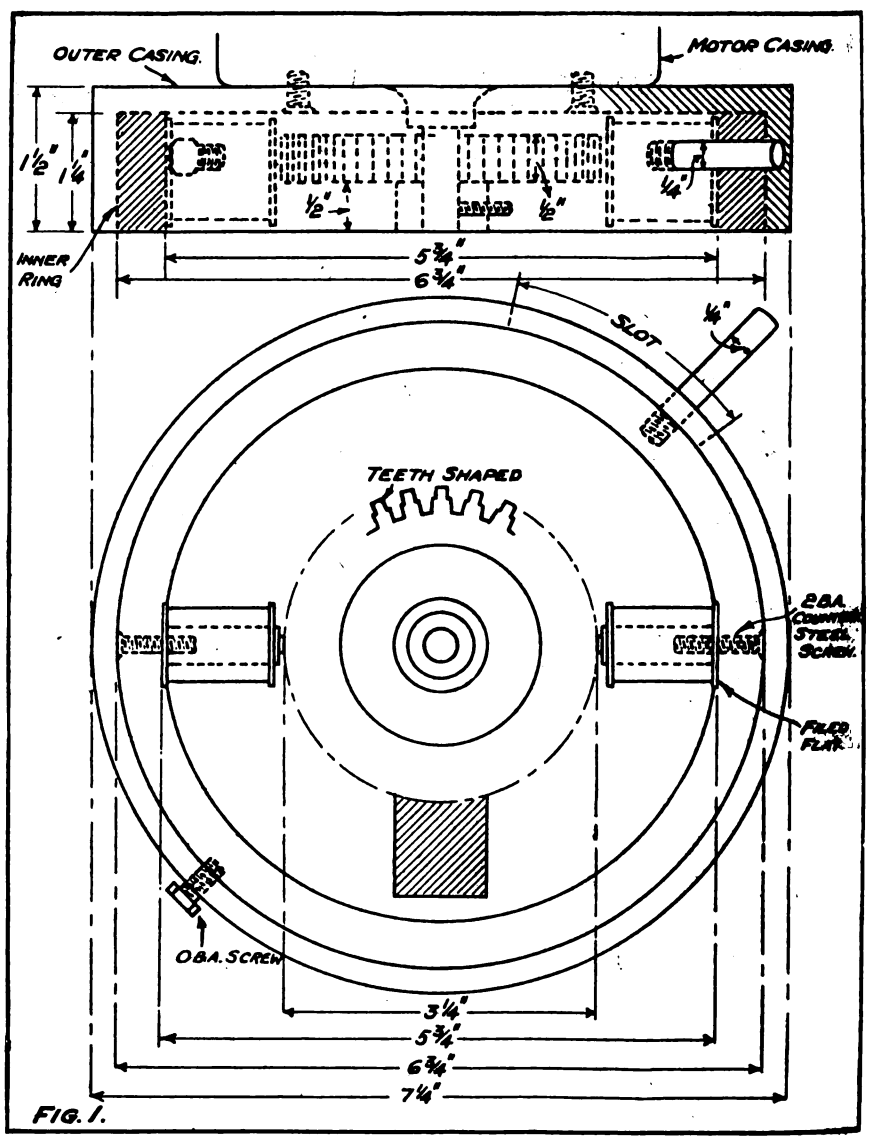

FIG. 1.

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to mount the phonic wheel. This wheel is an ordinary standard 30-tooth cast-iron gear wheel such as can be purchased from a machine-tool stockist for three or four shillings. The diametrical pitch of the teeth is not important but it should not be less than 3/10 of an inch, which will bring the overall diameter to approximately 3¼ inches.

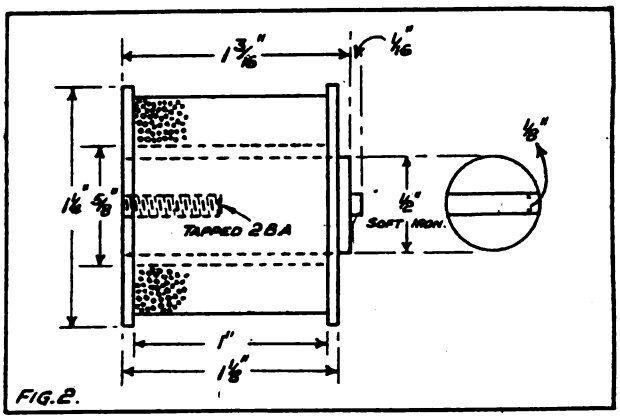

FIG. 2.

For those who prefer calculation:

If D is the outside diameter, N the number of teeth, and D^1 the diametrical pitch—

$$D^1 = \frac{N+2}{D}$$

The wheel is set up in the lathe and aced up on both sides to finish ½ inch in thickness. A light cut is then taken off the outside diameter and also a slight cut in the bore, which will bring the inside and outside circumferences concentric. It is then bushed to suit the diameter of the motor spindle, care being taken to make it a good push fit on to the spindle. The next operation is filing the teeth to a width of ⅛ inch approximately, and a 6-inch pillar file can be used with advantage.

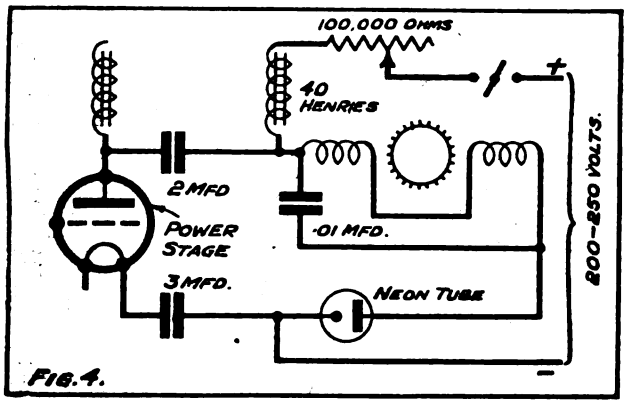

FIG. 4.

The outside casing shown in Fig. 1 is of cast-iron and should be machined to the dimensions given. The same applies to the ring which carries the electro-magnets. Patterns are made and castings obtained.

For the electro-magnets the bobbins are turned from 1¼ inches diameter ebonite rod and are wound full with No. 36 D.C.C. wire. The cores are turned from ⅛ inch soft iron rod and the ends that project from the bobbins are filed to the shape of the teeth of the gear wheel. All dimensions are given in Fig. 2. Care should be taken to make the cores exactly the same length.

In order to mount the wheel casing on to the motor a portion of the casing must be cut away to clear the projecting oiling system of the motor. This is done by marking off the portion to be removed and drilling a series of small holes that break into each other, and finishing off by using a half-round file. Where the casing fits on the flat surface of the motor it is fixed with three 2BA countersunk screws, the motor casing being tapped 2BA to receive them. The whole fixing is now concentric with the spindle.

The cast-iron ring carrying the electro-magnets should be an easy fit in the outer casing. This ring has a groove cut in its circumference into which a clamping screw is located to prevent the ring from rotating in the casing and to lock it in any desired position.

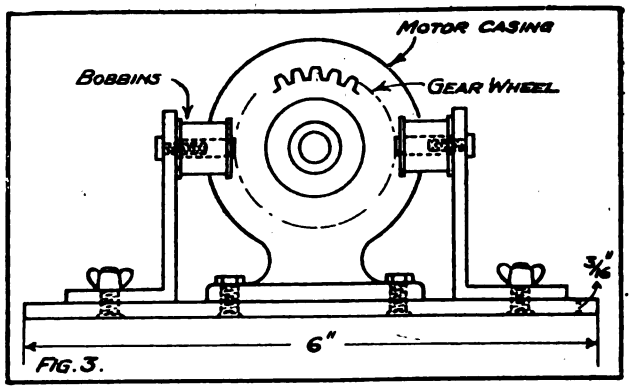

FIG. 3.

An elongated slot is cut through the outer casing and a small handle passes through the slot and is screwed into the ring. This is a device for putting the received image into phase with the transmitter. The motor speed is adjusted by the rheostat until the image is received, and if it is out of phase a movement of this phasing ring will bring the two parts of the image into their proper positions to form one complete image. The slot can be made of any convenient length, but a slot along one-quarter of the circumference will be sufficient. This arrangement is shown by the dotted lines in Fig. 1.

For a simpler method of construction lathe work is only required for the toothed wheel. The motor is mounted on an iron base plate that is large enough to support the brackets holding the controlling electro-magnets. The iron base plate is for rigidity and to serve as part of the magnetic circuit. 1 inch by ⅛ inch strip iron is suitable for the brackets. Slots are cut in the bases of the brackets to allow adjustment for the best position to be found by experiment. The brackets are held in position by bolts passing through the base plate and provided with wing nuts. (See Fig. 3.)

No phasing device is provided, but this is relatively unimportant in this simplified construction.

(*Continued on page* 574.)

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Television for the Beginner

PART I

By *John W. Woodford.*

HAS it ever occurred to you that the human race, whether civilised or uncivilised, is characterised by a certain "lag" in its acceptance of facts after they have been scientifically established by the relatively few brilliant geniuses who are rather the exception than the rule in this world? What is the reason for this? Can it be attributed to the fact that the average lay mind is not scientifically inclined, or is it the outcome of some inherent defect? No, I am inclined to the opinion that this state of affairs is brought about by "mental shock." When, after years of patient investigation, an inventor achieves some new wonder of which previously the public had heard nothing, the first news that comes to hand is the heralding in of a new era by bold headlines in the lay press, coupled with a flowery journalistic effort.

The public can hardly believe their eyes when they read the account, their mental activities have been directed in other quarters, and in consequence the achievement loses much of its potentiality. If the men and women could have been gradually educated to an anticipation of the new order of things, then they would have grasped the thorough significance of the new development, but this generally is impossible except in certain scientific circles.

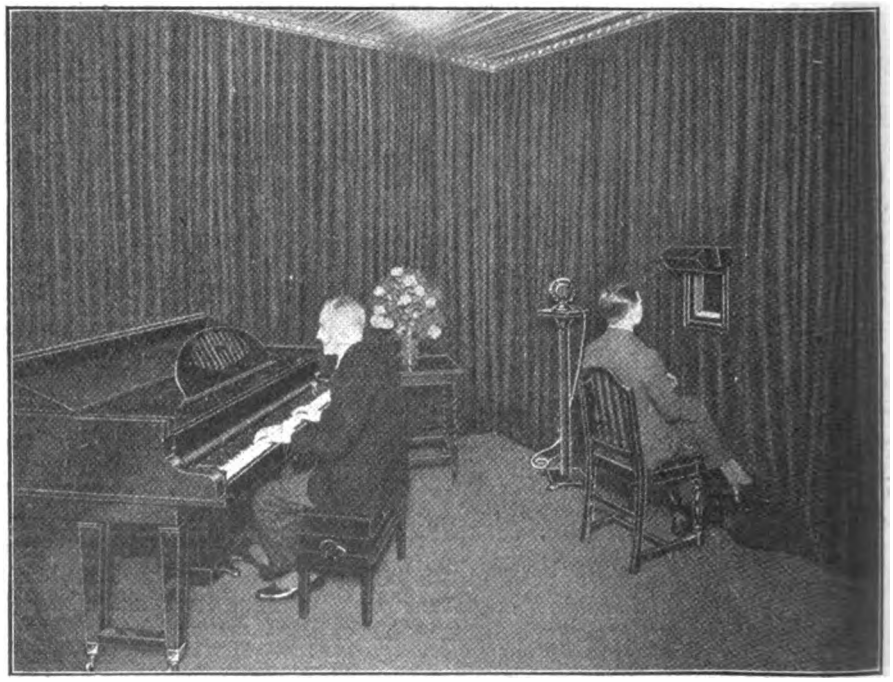
Pioneer Efforts Disregarded.

This natural complexity happens in every case. Witness Graham Bell's invention of the telephone. It was looked upon merely as an interesting toy, but the present generation has been born into a world which has grown used to its benefits and they, in consequence, accept it as part of their heritage. Remove the telephone and the whole world would be in a state of chaos, and business completely disorganised. The same thing occurred with wireless; in fact, every pioneering effort has to pass through vicissitudes almost incomprehensible before it emerges triumphant and is acknowledged by a sceptical world. Wireless received an unexpected fillip in its development owing to the Great War, otherwise it would have been safe to say that broadcasting as we now know it would have still been in the realms of fancy. And so we find the same with television!

While it would be ridiculous to wish for another war to bring home to people the benefits of television, and artificially hasten its acceptance as an accomplished fact, it must be deprecated that the full significance of its vast potentialities is only just beginning to dawn on people living outside the scientific circle.

Bordering on the Miraculous.

I must admit that the whole thing borders so much on the miraculous that the idea of seeing beyond the limits of normal human vision is a large pill to swallow. We have now got accustomed to hearing voices which have their origin hundreds or even thousands of miles



View of the television broadcasting studio in the Baird Laboratories.

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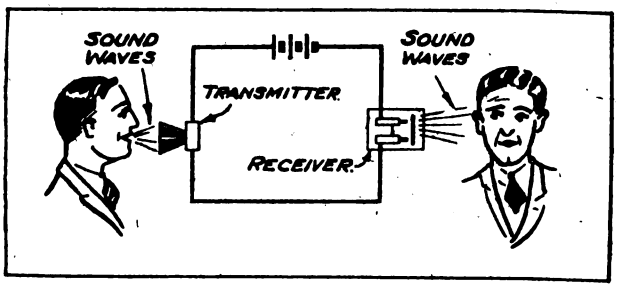
away, and with the aid of a fairly voluminous press the scheme adopted to bring this to fruition has been made fairly clear. A series of articles called " Bridging Space," which ran in this journal, also gave an elementary exposition of the forces at work to produce this state of affairs.

I learn from the Editor of TELEVISION, however, that there are many readers who are finding it difficult to understand how television is accomplished, and at his invitation this series of articles is being prepared so that the facts can be presented in as



A simple explanation of how sound is conveyed from one point to another.

elementary a manner as possible. This will pave the way to a fuller appreciation of the science against the day when we can purchase television receiving machines over the shop counter in just the same semi-casual manner as we now buy a loud-speaker. It is hoped thereby to educate all to a mental condition which will enable them to realise the full benefits that television has to offer, while eschewing any flights into those realms of fancy which the present state of the science makes no pretext to achieving, owing to limitations imposed mainly by inadequate broadcasting facilities and too small a kilocycle side-band allocation.

If some of my early remarks in this series add little to your existing knowledge bear with me, for the continuity of a subject is so often lost by the writer presuming that his reader must know this, that, or the other, and I am so conscious of the wonderful future that television is mapping out for us and the generation to follow that I am keen to do my bit and enlighten others so that they may enjoy its benefits unreservedly.

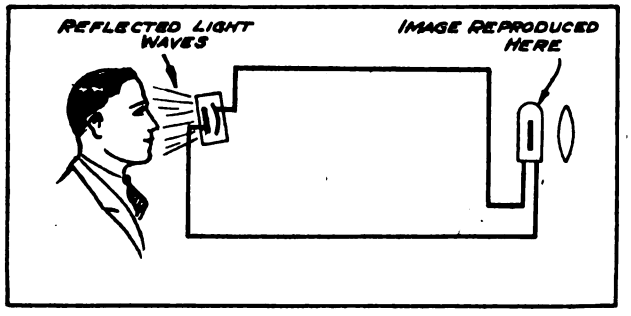
Conveying Complete Intelligence.

To encourage certain trains of thought it is desirable to appeal to as many of man's senses as we possibly can, but while feeling, smelling and tasting serve their parts in our everyday life, *complete* intelligence can be conveyed by calling into play the remaining two of our natural senses, namely, hearing and seeing. Whenever we use one of these without the other we approach the condition of either a deaf man left with the joy of sight, or alternatively a blind person relying upon his hearing. For this reason alone, television (which, to be scientifically correct, means seeing with the aid of electrical methods of transmission, the reproduction on a screen of the images of scenes, living or inanimate objects, without being actual eye-witnesses on the spot at which they occur) is so all-important.

Now there are certain analogies between the process of television and that of telephone communication between two individuals or of wireless broadcasting from studio to listener. If you speak into a telephone mouthpiece the sound waves of your voice impinge on a small diaphragm or metal plate, and cause it to vibrate in sympathy or in exact conformation to the sound waves. This varying movement of the plate is impressed upon carbon granules rather loosely packed at the back of the instrument, and consequently the electrical resistance of the circuit of which they form a part is altered. This sets up a fluctuating current which alters exactly in unison with the voice waves.

Making a Conversion.

In other words, we have converted speech in the form of sound waves into current alterations in a wire circuit, and these are sent along to the receiving end, where they pass round the coils of a magnet mounted behind another metal diaphragm. The action of this varying current is to alter continuously the attraction of the magnet on to the plate, and the resultant movements must perforce be in unison with those taking place at the transmitting end. These diaphragm vibrations therefore set up sound waves corresponding with the original speech established at the sending end of the line, and thus speech is reproduced. The process is really amazingly simple, but it took years to develop and our present day telephone service is based entirely on this method with, of course, refinements added to cope with the large volume of traffic a telephone exchange has to handle.



A similar explanation of how sight is transmitted.

Wireless Broadcasting.

With wireless broadcasting we have the same sort of thing taking place. The artist stands or sits in front of a sensitive microphone and the sound waves are converted by this device into electrical current variations. Being minute in character they are amplified and then superimposed (that is, made to modulate) upon the high frequency carrier wave of the station, this last named wave taking the place of the wires in an ordinary telephone arrangement. This complex electrical condition is radiated into space in the form of electro-magnetic waves, and providing you have a wireless aerial and its associated receiver

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tuned-in to the broadcasting station you can detect these waves, since they produce minute voltages in the aerial circuit. After being amplified in the set they are finally passed on to the loud-speaker, which operates on a similar principle to the telephone ear-piece, and we can thereby reconstruct an aural replica of what is taking place at the distant broadcasting station studio.

Television is Similar.

With television a similar sort of process is gone through. The person to be televised sits before the transmitting apparatus, and the light reflected from the face influences what is called a light-sensitive or photo-electric cell, and owing to its peculiar property the cell converts this reflected light into a current variation. Now, as in the two previous processes, this fluctuating current is sent from the transmitting to the receiving end by the aid of wires or wireless. At the receiving end the current variations are turned back into light variations by means of a special lamp, called a neon lamp, and with its associated apparatus this is recreated into an image of the person at the transmitting end. As in telephony no actual sound passes through the separating medium, so in television no actual light is transmitted, but merely an electrical replica in each case. The cells we referred to can be looked upon as acting in the nature of a sensitive light microphone, while the neon lamp and associated apparatus which recreate the image serve the eye in a manner similar to the loud-speaker which serves the ear.

Serving the Best Purpose.

Now the methods proposed to bring to successful fruition the apparently simple television scheme just formulated have been many and complex, but the first to achieve demonstrable results was J. L. Baird. The process he evolved has so far been the only one which has achieved distinction, it being essentially simple and yet commercial in character, so that while an examination of all the systems would be instructive, it is felt that in a series of this character such explanations would be irrelevant to the points at issue. I shall therefore deal with the Baird process of television for, after all, this is of the greatest importance to readers in this country, since the experimental television transmissions now being broadcast by the B.B.C. through the Brookman's Park station are by this process. Potential "lookers-in" will be best served, therefore, by examining the Baird system in all its details.

Experimental Television Apparatus.

(*Concluded from page 571.*)

The electro-magnets are actuated by the signal current, and therefore they are connected in series with the neon tube, as is shown in the circuit diagram, Fig 4. It will be found an advantage to connect a condenser of from ·001 to ·01μF capacity across the synchronising coils, to bye-pass the higher frequencies of the television signals to the neon tube, since frequencies above 375 ~ /sec. are of no use in operating the phonic wheel.

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South Africa has Seen—and Believes

LORD ANGUS KENNEDY, Vice-President of the Television Society, who went to South Africa with television apparatus to demonstrate at the meetings of the British Association there in August of this year, returned to England recently.

During his tour he demonstrated at Cape Town, Johannesburg and Pretoria, and met many prominent people.

"Great enthusiasm," he told a representative of TELEVISION, "was shown by the people of South Africa in the demonstrations. There is little doubt that television will have a great reception when it is put on the market there.

"The question of transmitting pictures, faces and objects by short waves from Europe to Africa and other remote places is probably not far distant. When the broadcasting companies can relay both the faces and voices of famous singers from Europe to every part of Africa there will undoubtedly be a great interest in broadcasting.

"At present the difficulties of providing a suitable programme from the rather limited local resources are a decided handicap. The possibility of both seeing and hearing performers in other countries was a point in connection with television which struck everyone who attended the demonstrations and appealed to them most strongly."

At every place visited, Lord Angus received the utmost assistance from the Government, the African Broadcasting Company, the Universities and educational authorities, and the municipalities. In every way his visit to South Africa had been a most enjoyable one.

Lord Angus has brought home with him a visitors' book containing over 800 names of persons who visited the demonstrations. This he permitted the TELEVISION representative to inspect.

To turn over its pages is to realise how very few words the English and Dutch languages provide to express surprise. On every page the words "wonderful," "marvellous," "surprising," "extraordinary," and "hardly believable" are as thickly scattered as daisies in an English meadow.

Far more interesting than these comments, however, is one entry which reads: "Splendid. My little girl, aged four years, recognised me and said 'Hullo, mummy.'"

Many of the visitors added after their signature, "Far better than we had been led to believe."

One wag wrote, "How this would increase the revenue of the posts and telegraphs in spring-time." "A most valuable invention. Dangerous to neglect it," wrote another.

Practically everyone of importance in South Africa from the Governor-General, the Earl of Athlone, down, has signed the book.

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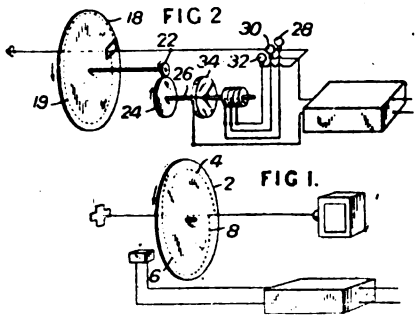
INVENTION *and* DEVELOPMENT

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. each.

Patent No. 319307, granted to J. L. Baird and Television, Ltd.: COLOUR TELEVISION. The exploring disc (2) at the transmitter (Fig. 1) is provided with different sets (4), (6), (8), of light



apertures, each set being allocated to a different colour and having appropriate filters. The receiver, shown in Fig. 2, has an exploring device (18) provided with a single set (19) of light apertures, suitable lamps (28), (30), (32), for providing illuminations corresponding respectively in colour to the colours at the transmitter, and a commutator disc (34), for rendering each illumination operative in turn in synchronism with the operation of the exploring devices.

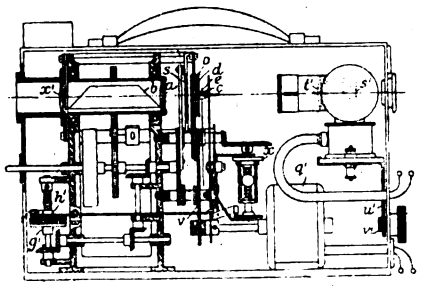


Fig. 3.

The exploring disc at the receiver is rotated at three times the speed of that at the transmitter by means of gearing (22), (24), from a shaft (26) synchronised with the driving shaft at the transmitter.

Patent No. 319454, granted to P. T. de Wet: EXPLORING METHOD, whereby an image of the object is caused to rotate, an elementary strip of the image is picked out by a *fixed* radial slot in a diaphragm, and the exploring is completed by the movement of further slots intersecting the former at right-angles. In Fig. 3, light from an object to the left passes through optical and scanning systems x^1, b, a, c, e, t^1, to a light-sensitive cell s^1, the position of which can be adjusted by means of the rack and pinion u^1, v^1. A set of lenses, appropriate to objects at different distances, are mounted in a turret. An image of the object is formed in the plane of a fixed diaphragm D (Figs. 3 and 4), which masks off all except a radial strip of the image admitted by a slot c, which may be tapered or not. The rays forming the image pass through a reflecting prism b which rotates so that successive radial strips of the image are selected by the slot c. This slot is intersected by further slots e^1 in a disc e rotating at high speed, so that the image is explored by the aperture formed by the intersection of the slots c, e^1.

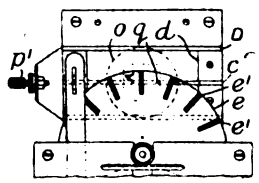


Fig. 4.

A gauze disc may be interposed; it is stated that this has the effect of making the picture current pulsate, or alternatively the light falling on the cell may be periodically interrupted.

A square aperture in a plate o, which is geared to rotate at the same speed as the image, serves to frame the picture, and carries a mark q for use in synchronising.

The above rotating parts are driven through gearing from a motor q^1 with governor x.

For *colour effects*, a screen s (Fig. 5), composed of two different filter plates s^1, s^2, is reciprocated vertically by a connecting rod in the form of a frame r, so that the plates s^1, s^2 are in position for alternate scannings of the picture. The diaphragm D formed with the horizontal scanning slot c co-operates with a shutter d having a slot, tapered

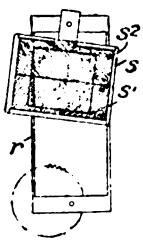
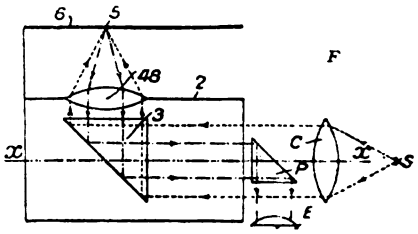


Fig. 5.

or not, and adapted to ensure that the picture is scanned along a radius and not along the whole diameter, for which purpose it abuts upon an adjustable stop p^1. While the apparatus is running the



shutter d is kept in its left position by linkwork controlled by the friction device g^1, h^1, but when the mechanism stops, the shutter d moves to the right and closes the slot s so that the light no longer reaches the cell. The receiver is similar in construction to the transmitter, a signal-controlled lamp being substituted for the cell.

Patent No. 319809, granted to G. M. Wright.—PICTURE-TELEGRAPHY. The feature of the method described in this Patent is that the same moving lens or equivalent optical device is used for concentrating the light on the picture and also for collecting the scattered or reflected light. In Fig. 6 light from a source S is collimated by a lens C, reflected by a prism (3) and focused at (5) on to the picture or message form (6) by a lens (48). The prism 3 and lens (48) are mounted within a rotating tube (2). Light reflected from (5) passes back through the lens (48) and prism

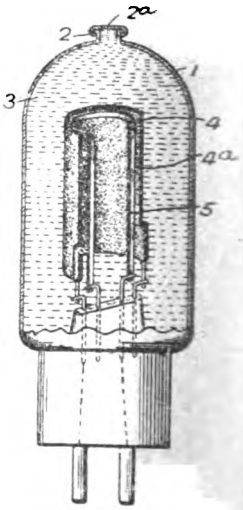


Fig. 7.

(3) and is now reflected by prism P on to a photo-electric cell E. The prism P may be replaced by a plane mirror extending across the tube (2) and having a central hole through which light from S may pass.

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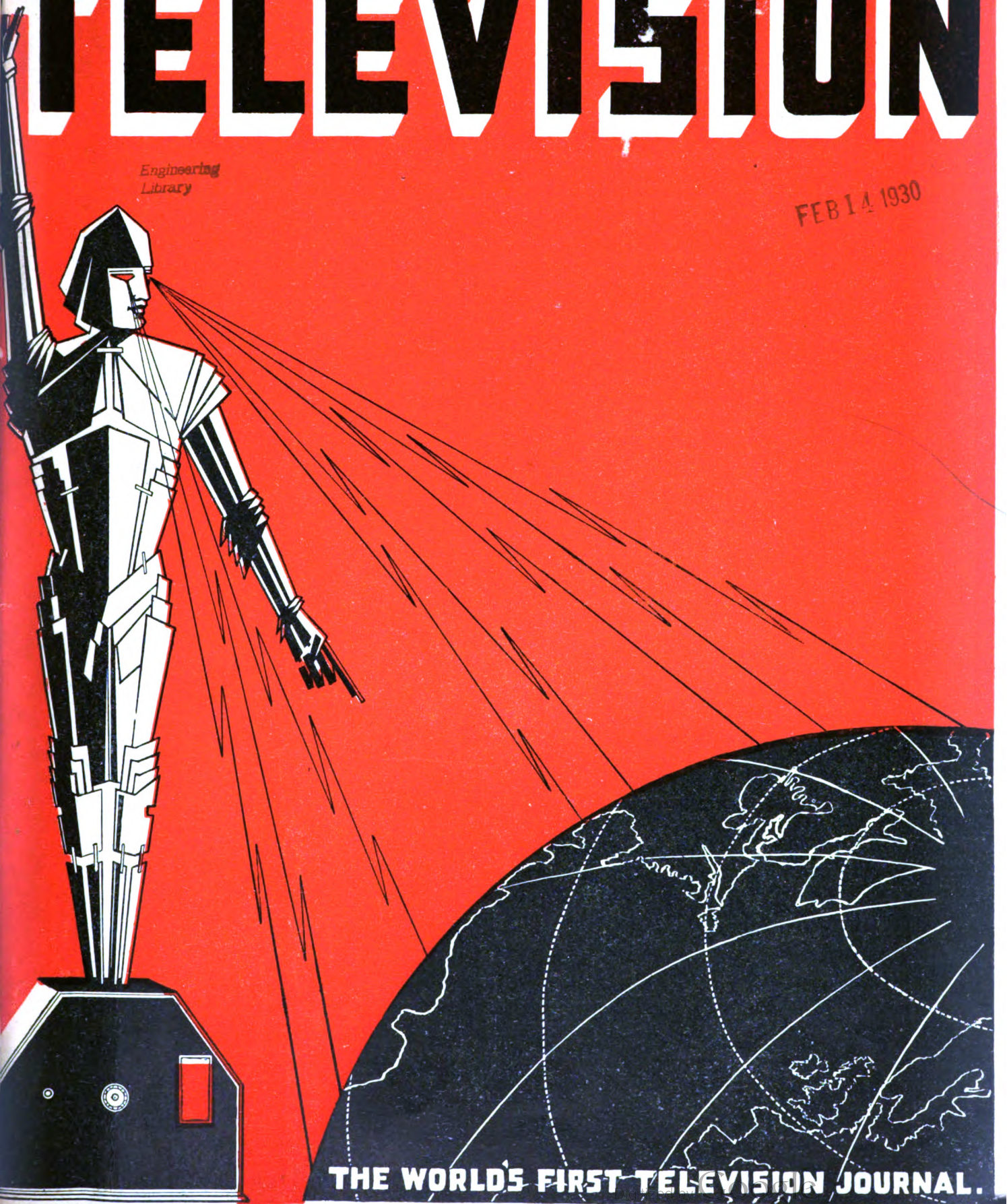

THE WORLD'S FIRST TELEVISION JOURNAL.

THE TELEVISION SOCIETY

The Television Society was founded on September 7th, 1927.

The Society makes its appeal to those who desire to share in the responsibility of furthering this new branch of applied science.

THE OBJECTS OF THE SOCIETY

may be summarised as follows :

(*a*) The Study of Television and its application in applied science and industry.

(*b*) To afford a common meeting ground for professional and other workers interested in current research relating to Television and allied subjects and to afford facilities for the publication of reports and matters of interest to Members.

(*c*) To encourage the formation of *Local Centres* of the Society in the Provinces, so that by social intercourse and discussion among members these aims may be more fully realised.

The present register indicates a world-wide membership.

ORGANISATION

The Society consists of one Honorary Fellow, Fellows and Associates, and the management is vested in a Council of Fellows, including the President, three Vice-Presidents, and Ordinary Fellows.

FELLOWS.—Ordinary Fellows must be elected by the Council. Candidates for the Fellowship must be proposed by two Ordinary Fellows, the first proposer certifying his personal knowledge of the candidate.

ASSOCIATES.—Any person over 21 interested in Television may be eligible for the Associateship without technical qualifications, but must give some evidence of interest in the subject as shall satisfy the Committee.

STUDENT MEMBERS.—The Council have arranged for the entrance of persons under the age of 21 as Student Members.

SUBSCRIPTIONS.—The annual subscription for Ordinary Fellows is 20s., with an entrance fee of 10s. 6d.; and for Associates 10s., with an entrance fee of 5s.

The annual subscription for Student Members is 5s., entrance fee 2s. 6d.

LIFE MEMBERS.—Life Membership may be secured at a fee of £10 10s.

MEETINGS.—The ordinary meetings of the Society are held in London at the Engineers' Club, Coventry Street, W.1, at 8 p.m., on the first Tuesday of the month (October to May inclusive). Notices of meetings are posted to all members about seven days before the meeting

Full-size reproduction of the new Television Society Badge, which is available to accredited Members, and may be obtained from the Head Office, price 1s.

The official organ of the Society is "Television," published monthly by the Television Press, Ltd., 26, Charing Cross Road, W.C.2.

A memorandum for the guidance of members wishing to form a Local Centre of the Society may be obtained (gratis) on application to the Joint Hon Secretaries, 4, Duke Street, Adelphi, W.C. 2.

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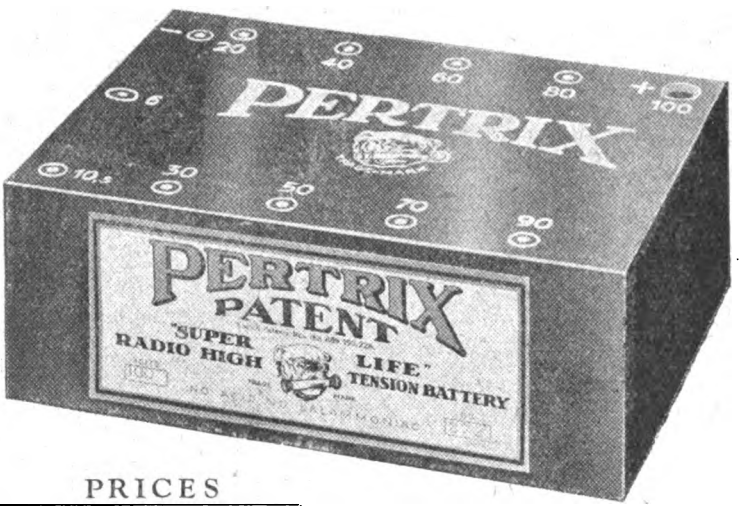

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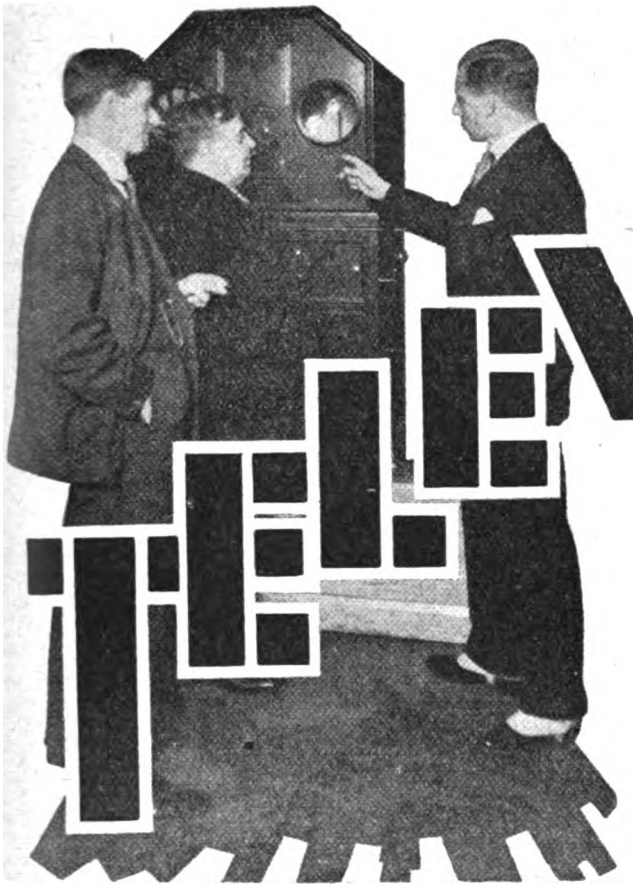

TELEVISION

THE OFFICIAL ORGAN OF THE TELEVISION SOCIETY

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VOL. II] FEBRUARY 1930 [NO. 24

EDITORIAL

CONSIDERABLE criticism has been directed at the experimental broadcasts of television which are being conducted daily by the Baird Company in collaboration with the B.B.C., the implication being that they are failing to fulfil any useful purpose.

We have already referred in these columns to a recent article appearing in a contemporary publication the author of which declared that, despite assiduous effort, he had failed to secure any results whatever in his attempts to receive the television broadcasts. Our editorial comments with regard to this may be recalled.

In this connection, therefore, readers will be interested in the various reports of successful amateur reception from unsolicited sources as far afield as Berlin. We cannot speak too highly of the important work which these amateurs are doing. Their testimony is surely the best possible answer to those critics who have been so ready to throw cold water on something which, apparently, they know but little about.

But whilst the uninformed have been quick to criticise television, it is significant that Sir Ambrose Fleming—one of the most outstanding scientists of our time—has not only recognised the value of the achievement in its existing form, but has gone out of his way to help forward the invention by suggesting lines of development along which it may progress.

His lecture, delivered at the invitation of the Physical and Optical Society, and reprinted in this issue, is as lucid an exposition of the science as it would be possible to imagine. It is the product of a fine mind and should do much to lead those who are unacquainted with the subject to a complete understanding of its methods.

By kind permission of the Editor of *Nature*, we reprint in this issue a most illuminating and epochal article by Sir Ambrose Fleming, which appeared in that journal on January 18th. Under the somewhat mundane title "The Wave-band Theory of Wireless Transmission," Sir Ambrose hits out at one of the most fundamental theories on which modern wireless transmission is based; neither does he fail to show how the future of television

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is being harassed and retarded by a mistaken view as to the real nature of wireless waves.

In order to add point to Sir Ambrose's article it may be *a propos* to draw attention to the remarkable association which he has had during the last half century or so with new inventions. Let us consider first the case of incandescent electric lighting.

In a small basement room in Victoria Street, London, he gave a demonstration of incandescent electric lighting by means of the first filament lamp to appear in this country. Not long afterwards he was present at another demonstration, this time at the Crystal Palace, which was attended by some of the leading gas-lighting engineers in the country. These gentlemen were unanimous in the opinion that, whilst the incandescent electric lamp was unquestionably a wonderful invention, under *no* circumstances would it ever become a means of providing light in the home!

Take another case. When Bell invented the telephone it was Sir Ambrose Fleming who used the first instrument to arrive in this country, when by its means he conversed between London and Streatham.

Coming to a more recent invention — wireless telegraphy—we find Sir Ambrose closely associated with Marconi during the course of some of his earliest experiments. Perhaps the most famous, and certainly the most spectacular, of these was the initial transmission of the letter "S" across the Atlantic, twenty-eight years ago.

As the years passed, his interest in problems relative to the development of wireless communication increased and resulted finally in his invention of the Fleming Valve, the prototype of the modern thermionic valve which has made possible, not only broadcasting and television, but all forms of long-distance electrical communication as at present practised.

It was in May, 1928, that the veteran scientist first honoured these pages as a contributor. Ever since that time, as our readers well know, he has been a staunch supporter of the Baird system of television.

From the brief outline which we have given above, it will readily be appreciated that we of the present generation owe a considerable debt to Sir Ambrose Fleming for the support which he has given, in their embrionic state, to inventions which led ultimately to the production of what are now regarded as everyday appliances and necessities. Future generations will owe an equal debt of gratitude to him for his great foresight and support of this new departure from accepted theory concerning wireless waves.

The revolution which will be brought about in electrical communication by the acceptance of this new theory is surely as phenomenal as any since the historic pronouncement of Copernicus that it was the earth which went round the sun.

It is good to know that the man who has already given so much to his day and generation is still pointing the way to a future generation by giving his support to a new understanding of wireless waves and television.

So much for the more technical aspects of the science.

During the month that has gone the public have been given two opportunities of seeing practical demonstrations of television—at the *Daily Mail* Schoolboys' Exhibition and at the Exhibition of the Physical and Optical Societies. Both demonstrations were carried out by the Baird Company and were marked by the reception of some really clear images. In the case of the Schoolboys' Exhibition the transmission was effected by land-line between the Army and Navy Stores and the Horticultural Hall, a distance of not more than a few hundred yards.

The demonstration at the Physical and Optical Societies' Exhibition, on the other hand, was carried out between the headquarters of the Baird Company in Long Acre and the Imperial College of Science at South Kensington. This involved transmission by land-line over a distance of nearly three miles, the line having to pass through no less than three post-office telephone exchanges *en route*.

With the announcement that the Baird Company is about to place receivers on the market, we may well believe that it will not be long before the public will reap the benefits that will usher in a new era in communication. If development in the immediate future is as rapid as we have reason to hope, then the years of waiting and working will not seem so very long after all.

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Television

PRESENT AND FUTURE

A Lecture given at the Imperial College of Science, London, on January 9th, 1930, at the Annual Exhibition of Apparatus by the Physical and Optical Societies of London

By *Sir Ambrose Fleming*, F.R.S.

IN speaking to you this evening on the subject of television, present and future, I shall not occupy time with any historical retrospect.

The story of the various attempts made to transmit to a distance visual images of actual living or moving objects as against simple picture transmission or telephotography can be read in the pages of several excellent books already published on this subject.*

Neither shall I dwell on the various proposals for television apparatus which have been put forward, but not put in practice. Nor with those which have been put in practice with only very imperfect success in transmitting mere shadowgraphs but not true television images.

There will be quite enough to occupy our attention in a brief hour if I endeavour to give you a short account of the principles of television apparatus as now used in successful performance at present and discuss some of its possible improvements in the future.

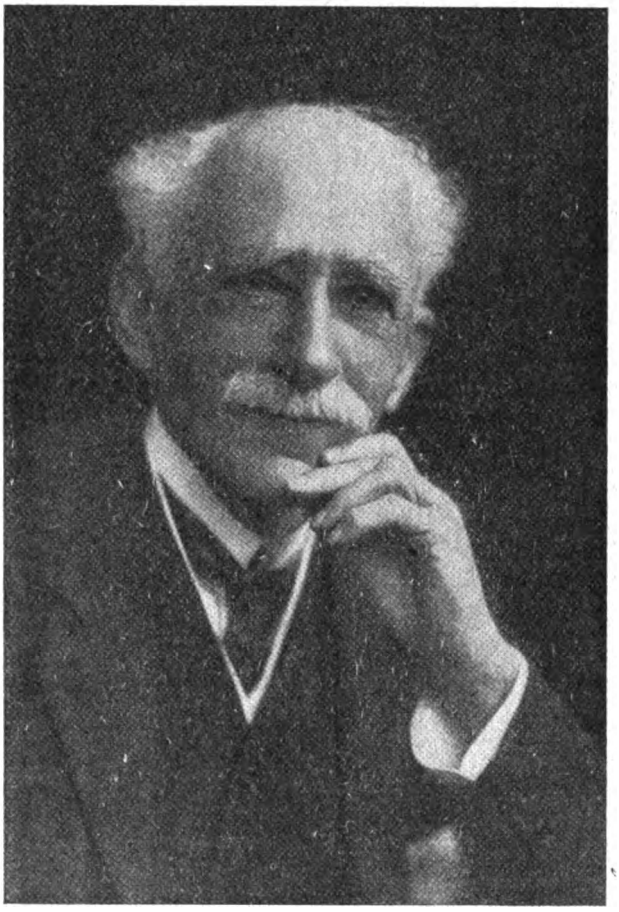

Photo. Lafayette.

A recent photograph of Sir Ambrose Fleming.

The first statement which must be made is that television, in any true sense of the term, depends essentially on a certain special property of the human eye of which we are not generally conscious.

The one essential quality of the eye on which it depends is that of persistence of vision, or the fact that a visual stimulation produced on the retina of the eye does not vanish immediately when the stimulating light ray is withdrawn.

The structure of the eye is that of a photographic camera. We ought not to say the eye is like a camera, because eyes were in existence before cameras, but the camera is modelled on the eye.

The crystalline lens of the eye forms an inverted image of external objects on the retina or interior of the back wall of the eyeball.

The retina, in addition to a close network of nerves and blood vessels, has a very complex structure in which microscopic examination detects 8 to 10 layers of tissue. The next but one to the surface contains curious bodies called rods and cones. In the outer parts of the rods a fluid called the visual purple is found. The surface layer of the retina consists of

E.g., "Television," by Alfred Dinsdale. 5s. Television Press, Ltd., London; or "Practical Television," by E. T. Larner. 10s. 6d. Ernest Benn, Ltd., London.

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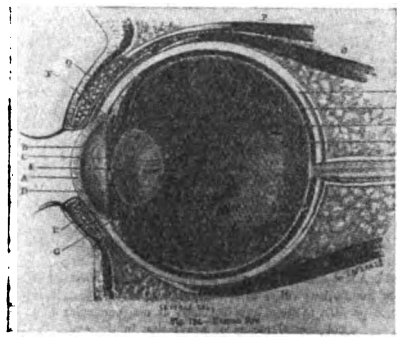
hexagonal cells containing some colouring fluid or pigment.

There are three important regions of this retina. One, called the *fovea centralis*, is particularly sensitive to light and rich in rods and cones. Another, called the "blind spot," has no rods and cones and is insensitive to light. This marks the place of entry of the optic nerve. It is also called the optic disk. Another part, known as the "yellow spot," is characterised by a yellow pigment.



Cross section of the human eye.

When we look at any source of light or illuminated object the eyeball is automatically moved by muscles controlling it so as to bring the various parts of the image of the object we wish to see on to the *fovea centralis*.

In reading print or looking at a large object the eyeball is being continually moved so as to cause the image to rove over the retina and bring each part in turn on to the sensitive spot.

When that spot has been stimulated by light the effect does not vanish at once on the withdrawing of the light or change in the position of the eye, but lingers for a fraction of a second before the retina at that part is again ready for use.

This effect, known as persistence of vision, gives the explanation of many well-known optical and ocular effects.

If, for instance, a single bright spot of light moves in a circle or in a straight line very quickly we cease to see a single spot, but see a circular or straight line of light of a certain length. A meteor shooting across the sky appears as a line of light and a lighted squib whirled round in the dark as a circle of light.

The colour top of Maxwell for blending colour depends on the same principle. The retina of the eye behaves to a certain extent like a sheet of paper covered with Balmain's luminous paint.

Illustrating Persistence of Vision

If we were to throw on such a painted screen the image of a letter or pattern cut in a stencil plate, put as a slide in an optical lantern, this luminous letter would excite the paint and if the light beam was extinguished or stopped the letter or pattern would be seen still glowing for a certain short time, but would rapidly fade away. Then another luminous letter or pattern could then be impressed on the screen in place of it.

It has been suggested that the visual purple in the rods acts in some way like this phosphorescent paint. It appears from tests made that in various persons the degree of persistence of vision is different. In some people it is much less than in others.

This, suppose we were to have a cross-word puzzle painted on a large card and hung up in a dark room.

Imagine that from a lantern a slender beam of light was projected only just large enough to cover a single black or white square, and that it could be moved successively along each line of the puzzle. If it moved slowly we should only see a single square whether black or white at a time. If it moved quickly enough we might see a whole line at a time in proper order, and if it completed the whole of its journey in the sixteenth of a second and repeated them sixteen times in a second we should see the cross-word pattern complete as a whole in virtue of this persistence of vision.

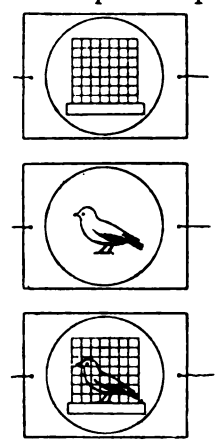
Consider in the next place a human face or any other object placed in the dark. Let a slender beam of light be projected on to it and create on it a brilliant spot of light. Let this light spot move downwards over the object and then repeat its journey a second time, slightly more displaced, say, to the right, but so that the successive spot paths just touch each other.

Imagine this shifted journey repeated again and again, say 30 times, so as to cover the whole object in time.

If this light spot journey is performed slowly we should see nothing but a spot of ever-changing colour and brightness varying from perfect whiteness to perfect blackness according to the nature of the surface over which it was at that moment moving.

Scanning Explained

If, however, the whole set of its journeys is performed in, say, one sixteenth of a second we should by persistence of vision see the whole face completely. Imagine next that we could in some way create at a distant place a spot of light which shall move over a screen exactly in step and time with the spot at the sending end just like two distant clocks each showing exact Greenwich time. If the sending-end spot moved quickly enough to cover the whole of the object in one sixteenth second and repeated its set of journeys sixteen times a second, and if the spot at the receiving end kept exact step with the sending-end spot, and, moreover, if the receiving-end spot could be made to have the same brilliancy and colour at the same instant as the sending-end spot, we should have an exact reproduction at the receiving end of the object or face and true television would be achieved. We have then these three things to consider :—



A simple experiment illustrating persistence of vision. If a bird is drawn on one side of a card and a cage on the other, and the card is rapidly rotated by strings attached to the sides, the bird will appear inside the cage.

1. How such a travelling spot of light can be produced at the sending end ?
2. How its brightness and colour can be reproduced instantly at a distant place ? and,

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3. How the reproduced spot can be made to move exactly in step and identically with the sending-end spot ?

In the first place the most convenient method, and as employed by Mr. Baird, to produce the travelling spot or scanning spot, as it is called, at the sending end is by the use of a scanning disk with small holes in it arranged equidistantly along an equiangular spiral of one complete turn. It is usual to employ such a disk with 30 holes. This type of disk was first suggested by Nipkow in 1884.

How a face is scanned by a tiny spot of light.

The reduction of radius of the spiral in one turn of 360° is called its pitch, and the diameter of the holes must be such that if there are 30 holes each must have a diameter equal to the thirtieth part of the pitch.

This disk is fixed to an axis and rotated uniformly by an electric motor at not less than 16 revolutions a second, or say 1,000 per minute.

The disk is placed in the path of a beam of light so that by an objective lens a spot of light is focussed upon the object and moves downwards over it as the disk revolves. Only one single spot must be on the object at a time.

This necessitates a brilliant but perfectly steady source of light and Mr. Baird prefers to use high candle-power incandescent lamps.

This small bright spot of light causes no inconvenience when it passes rapidly over the human face, and indeed one is almost unconscious of it when being scanned.

Generally speaking, the lantern, disk and motor are placed in one room and the scanning ray passes through a small opening in the wall and falls on the face of a subject sitting before a screen in an adjacent room.

Leaving for a moment the arrangements at the receiving end, we have next to consider the method by which the scanning spot is made to produce an electric current of an intensity proportional to its brilliancy or to the illumination of the surface on which it falls. This is achieved by a photo-electric cell.

Discovery of Photo-electric Emission

As a consequence of a fact noticed by Hertz in some of his work, Hallwachs discovered in 1888 that when certain metal surfaces are illuminated by light of a certain kind they give off electrons or lose negative electricity. This is called photo-electric emission.

To catch up this current it is necessary to place a metal grid before the sensitive metal plate and to illuminate the plate through the grid. If a battery and galvanometer are connected to the plate and grid respectively, the negative pole of the battery being connected to the plate, then when the plate is illuminated by ultra-violet light a continuous current of negative electricity flows across from plate to grid.

To make a long story short, it was before long found that the electro-positive alkali metals—potassium, rubidium, cæsium—give the largest currents with visible light, especially when treated in a certain way.

A commercial form of photo-electric cell is therefore as follows.

A glass bulb rather flat on one side has this flat side coated inside with a thin deposit of silver or copper by well-known processes. This metal film has a deposit of potassium or cæsium made upon it which may be subsequently specially treated to make it more sensitive. In front of this photo-electric film is placed a ring of metal covered with a grid of fine wires, and connections are made to external electrodes with the grid and film.

The bulb may be either very highly exhausted of its air, in which case it is called a vacuum cell, or else it may be filled with an inert gas, generally argon or helium, at a low pressure of about one-sixth of a millimetre of mercury.

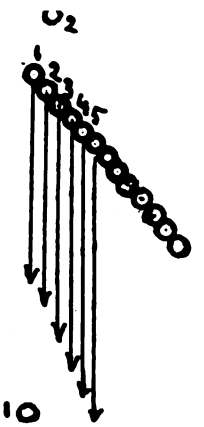
The vacuum cell is much more constant in operation than the gas-filled cell, but the latter is generally more sensitive than the former. Hence vacuum cells are used in scientific measurements, and gas-filled in commercial work.

A usual type of cell consists of a thin layer of potassium deposited on copper. In other cases the cathode, as it is called, is a thicker layer of potassium sensitized by a treatment consisting of making an electric discharge to it through hydrogen gas.

A far more sensitive photo-electric cell has been developed by the General Electric Company of London at their Research Laboratory at Wembley, consisting of cæsium deposited in oxide of silver. In its best form it is ten times more sensitive than the potassium-on-copper cell.

When the cathode or sensitive surface of such a cell is exposed to light, the grid having a certain positive potential, electrons are given off from the film and create a very feeble current of about 1 to 10 microamperes or so which passes in the cell from film to grid. This current can be amplified by thermionic valves.

This photo-electric current is proportional to the total amount of light falling on the cathode and is measured in amperes per lumen.



Showing how the travelling light spot produces adjacent vertical lines.

Photo-electric metals differ very much in the kind of light (that is the wavelength of the light) to which they are sensitive or to which their sensitivity is a maximum.

Thus, pure potassium is most sensitive to violet light. Potassium-on-copper is sensitive up to the red end of the spectrum.

Some curves prepared at the General Electric

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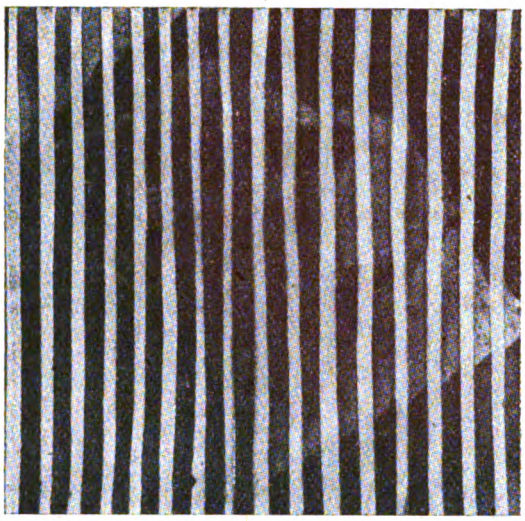
Company's Research Laboratory show the variation in sensitivity of different cathode materials over the entire wavelength range of visible light from 4000 A U to 7000 A U. (I A.U. 10^{-8} cm.). Such a photo-electric cell is then an artificial eye. But it is an eye with absolutely no persistence of vision.

When the incident light is withdrawn the photo-



What a television image would look like if the image strips were separated out.

electric emission does not continue even for the millionth part of a second.

The photo-electric current starts at once on illumination of the cathode and stops at once on its withdrawal, and varies within certain limits exactly in proportion to that illumination.

Hence this artificial eye is the very thing required for television.

Return now in thought for a moment to the face or object being scanned by the travelling spot of light. At every instant light is being scattered from the place over which the spot is passing and the amount of that light varies with the nature of the surface. Where the spot is passing over dark hair, eyebrows or shadows the scattered light is small. When it passes over white forehead or teeth the light is large.

A battery of photo-electric cells can therefore be so placed and shielded from direct rays as to pick up this scattered light and translate it into its equivalent in an electric current.

This current can be amplified by thermionic valves or amplifiers and either transmitted by telegraph wire to a distant place, or used to modulate a high frequency or carrier wave transmitted by wireless to a distant place.

In either case we have a current produced at the receiving station which varies in strength exactly in proportion to the intensity of the light scattered from that point of the object over which the scanning spot is then passing.

We have next to see how this varying current is translated back again into varying light.

Up to the present only one method has been found of doing this, viz., by means of a glow light neon tube. Neon is one of the rare monatomic gases in the atmosphere forming about one eighty-thousandth part of it. When an electric discharge is sent through rarefied neon gas the tube glows with a rich red orange light.

We are very familiar with this red neon glow effect in the glass tube shop-signs so much used now at night, in which glass tubes filled with neon, one bent into the form of various letters and words, are illuminated by a high tension alternating current.

If two metal plates are placed parallel to each other in a glass vessel and about one millimetre apart, then when the tube is filled with rarefied neon at a certain pressure, and the plates connected to a voltaic battery, it has the peculiar property that at a certain gas pressure no electric discharge can pass from plate to plate across the one millimetre space. The discharge prefers to go the long way round from the back of one plate to the back of the other.

There is a certain starting voltage of about 200 or 300 volts at which this discharge just begins and coats the back of the negative electrode plate with a very faint yellow glow. If on that voltage another voltage is imposed then the glow increases in brilliancy just in proportion to the added voltage. This action is perfectly instantaneous and there is no sensible lag.

Accordingly this neon tube provides what is required in television reception.

Suppose we look at the negative cathode not directly, but through the holes in a spiral-hole scanning disk, which runs exactly in step with the disk at the sending end, and if the added voltage to the neon tube is given by the amplified photo-electric current rendered by the "artificial eyes" which are looking at the object or face being scanned the neon glow will fluctuate exactly in proportion to the light scattered from the surface over which the scanning spot is then passing.

The same picture with the strips closely fitted together, as seen on the receiving screen.

If, then, the two spiral-hole or two Nipkow disks run exactly in step we shall have reproduced at the receiving end by persistence in the observer's vision an image of the object scanned.

Although this, taken as a whole, is a complicated process, it succeeds remarkably well in reproducing images of living human faces which are smiling, laughing, or making other motions; and also the heads of animals and other things can be televised as well.

We have then to explain how these two spiral-hole

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disks at the sending and receiving stations are synchronized or made to run in step.

Before we can do this I must call your attention to the exact mode in which the reproduced image of the distant object is built up.

There has been in the past much misunderstanding created by the assumption that the television image consists of a set of " dots " like a process block illustration. If you look at such a printed picture in a newspaper you will see it is composed of dots of ink, very black, and close together in the dark parts of the picture, and very faint or far apart in the light portions.

To obtain a recognizable portrait we must, therefore, have not less than a certain number of dots per square inch, say 2,500. If this were the case with television images it would mean at least 40,000 electric impulses per second for television, and probably more. But as a fact there are no " dots " at all in the television image.

Strips, not Dots

It is in reality built up of a series of closely adjacent lines of light, say 30, corresponding to the number of holes in the scanning disk. Each line of light varies in brightness along its length quite continuously without breaks or interruptions, and it is repeated at regular intervals about 16 times a second.

It is easy to prove this as follows:

If you look in at the image in a Baird receiver and, whilst keeping your head still, quickly move your eyes from one side to the other you will see the image break up into lines of reddish light. Otherwise if you look at the image, not directly, but by reflection in a little mirror, and give this mirror a sudden twist about a vertical axis, you will see the reflected image break up into a set of bright lines each varying in brightness along its length. These are called the picture elements.

Now between each complete line or single scanning of the object there is a very brief pause, which shows itself as a black or bright strip at the bottom of the picture.

If these facts are held in mind it will be easy to follow a description of the process adopted by Mr. Baird for synchronizing the sending and receiving disks.

These two disks may be compared with two distant clocks the hands of which go once round in the one-sixteenth of a second. We have to make these two clocks both go at the same rate, and show the same time. This is called the problem of synchronization or time-keeping.

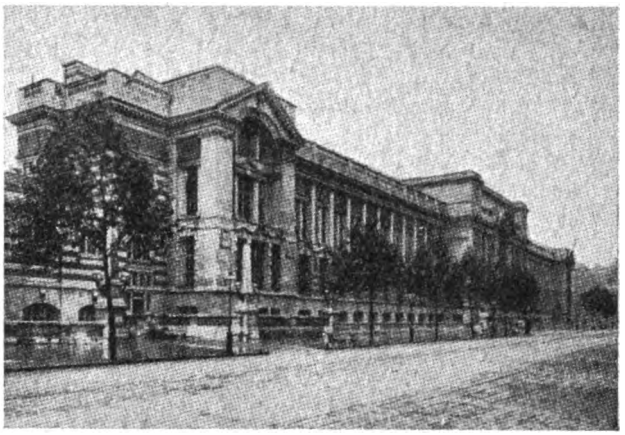
The Problem of Synchronism

The problem of synchronism has long been one of the outstanding problems which has prevented television from becoming a commercial reality. Various methods have been proposed.

The one which was first successful was the use of A.C. synchronous motors. This device gives quite successful results, but it necessitates the use of a separate channel of communication for the alternating current driving the two motors, as both motors must be driven from the same source.

In America use has been made of the alternating current electric supply mains, and where the transmitter and receiver are put on the same network synchronism may be achieved by this means, but it is only within very restricted areas that the same source of alternating current is available, so that this does not provide a solution to the problem.

Efforts have also been made to obtain synchronism by means of independent oscillating systems, such as oscillating crystals, tuning forks or oscillating valves, the alternating current generated by these devices being amplified and used to supply synchronous motors. Such devices are extremely complex and expensive, and are only suitable for operating under laboratory conditions, or where an expert staff is available, and are quite impractical for use by the general public.



The Imperial College of Science and Technology, departments of chemistry and physics, where the Physical and Optical Societies' Annual Exhibition was held, and where Sir Ambrose Fleming gave his lecture.

Therefore, before television could become commercially practicable for broadcasting to the home, some form of synchronism had to be devised which would not necessitate the use of separate channels of communication, and would be sufficiently simple and inexpensive to come within the powers of the domestic user. This was accomplished by Mr. Baird, and was shown in operation during the Radio Exhibition in September 1928, and was further publicly demonstrated at the demonstration given in March 1929 before the Committee of Members of Parliament and Post Office and B.B.C. engineers, when television was transmitted through 2LO and received at St. Martin's le Grand, before Lord Clarendon, the Postmaster-General and engineers and Parliamentary Committee, and was received simultaneously at Savoy Hill before Sir John Reith and officials of the B.B.C. On these occasions no separate synchronizing signal was sent out, the picture being transmitted through 2LO and the speech sent out through the Marconi Station on a separate wavelength, the picture itself providing the synchronizing impulses necessary to keep the receiver in step with the transmitter.

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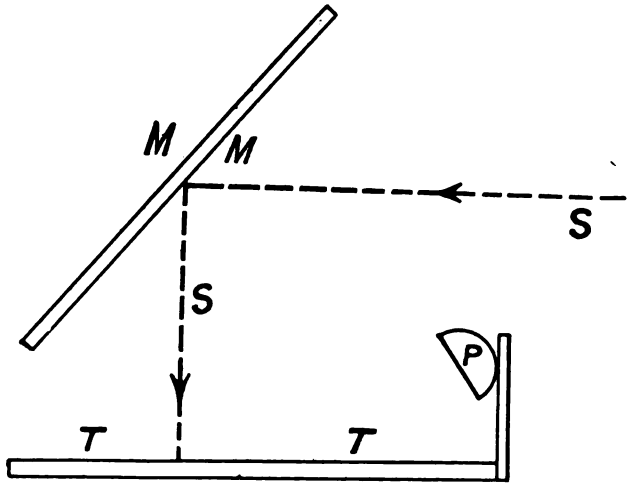
The synchronizing is accomplished by taking a portion of the picture-building current and using this to keep the receiving disk in step. Where a large receiving disk is used a commutator directs this current through a relay circuit for a brief interval at the end of each line of the picture. For example, if there were 30 lines in the picture the commutator sends 30 brief impulses through a relay during each reproduction of the image. Now, in operation, the action is as follows:—

Between one image and another there is a black division. This black division is not artificially produced, but is the natural demarkation between one picture and another. Now, when the machines are in synchronism the commutator connects the relay just at this black space; therefore, no current flows through the relay. If, however, the receiver goes slightly faster than the transmitter, the commutator comes into action at a lighted portion of the image and current passes through the relay, giving a small retarding force. The receiving machine is arranged to run very slightly faster than the transmitting machine, so that by means of the relay a perfect keeping in step is effected.

The above synchronizing mechanism is simplified in the smaller commercial machines supplied to the general public. In place of a commutator and relay, the correcting signal is applied directly to the coils of an electro-magnet which acts upon an iron wheel having little teeth corresponding to the holes in the scanning disk. Thus, when the receiving disk runs too fast, the correcting impulse pulls directly upon the iron teeth and opposes the motor. The scanning disk in the receiver is set to run a little faster than the disk of the transmitter, and the action of the electro-magnets on the toothed wheel retards it a little if the disks get out of step.

By these ingenious methods Mr. Baird has solved the problem of a simple yet perfectly practical synchronization, and in the best modern Baird receivers, when properly adjusted, the received image is perfectly steady and quite sharp and clear, and every motion of the object reproduced.



Arrangements for scanning objects on a horizontal Table, TT. M, *large plane mirror inclined at 45°;* SS, *scanning ray of light;* P, *photo-electric cells.*

We can in this way see, for instance, the image of a cat lapping her milk, or a dog barking or moving his ears, or any movements of a human head or face at a distant place. In other words, true television as compared with simple static picture transmission.

Now, an object in motion or alive is always more interesting to the general public than any mere stationary picture, and hence there is a great attraction in seeing at a distance such objects.

Nevertheless, there are only a limited number of objects which can " sit-up " in this way in front of a screen.

There are a number of objects and experiments which could be televised only when placed in a horizontal position. For instance, we might wish to show the lines of magnetic force of a magnet rendered visible by iron filings sprinkled on a sheet of paper laid over the magnet. Or we might wish to show the ripples on a mercury or water surface produced by touching it with a tuning fork or vibrating needle.

How it can be Done

I suggested lately to Mr. Baird that this could be done by placing over the horizontal object a large plane mirror or looking-glass at an angle of 45°, so as to reflect the horizontal scanning ray vertically downwards.

Thus photo-electric cells would then have to be placed in such a position as to pick up the scattered light, but at the same time be shielded from direct rays.

Another important problem which has to be solved in the future is to be able to transmit images of objects covering a large area. At present we can only televise small-sized objects such as a human head or something of the same size.

But we require to be able to transmit images of full-length human figures and of two or more people, or of a cricket match or football match or other scene.

It seems to me that the only way in which this can be done is by forming a small image of the large object by means of a large convex lens or concave mirror and scanning that image by a spiral-hole disk. But large achromatic lenses suitable for this purpose would be very expensive articles, and perhaps out of the question. The eminent engineer, Sir Charles Parsons, has however directed his attention of late years to the production of silver-on-glass concave mirrors of very large size, but not of enormous price.

A mirror of this kind, seven feet in diameter, was exhibited at the Parsons' stand in the Newcastle-on-Tyne Engineering Exhibition this last summer (August 1929).

My suggestion, then, is that if such a large mirror were placed with plane vertical it would be possible to reflect on to it by another plane mirror light sent out from a large object. The mirror would form a small image, the size of which would depend on the focal length of the mirror and the apparent angular diameter of the object.

The converging beam of light reflected from the mirror could then be turned out at right angles by a small mirror as in a Newtonian telescope, and brought

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to a focus on the surface of a scanning disk. Close behind the holes of this disk must be placed the most sensitive form of photo-electric cell with cathode plate large enough to contain the whole of the image formed by the mirror.

Then this image could be scanned in the usual way, and if there was light enough could be televised. I have considered whether it would be possible by this means to televise the moon or a solar eclipse.

In the case of a concave spherical mirror the angular diameter of the image as seen from the centre of curvature of the mirror is the same as the angular diameter of the object as seen from the same place. The sun and moon have an apparent angular diameter of about thirty minutes or half a degree.

If then a concave mirror of 20 feet radius of curvature or 10 feet focal length is employed as above described, it would form an image of the full moon about 1 inch in diameter. This could be formed on a suitable scanning disk with a highly sensitive photo-electric cell placed close behind it having a cathode at least 1 inch in diameter.

The image would then be scanned, and the resulting photo-electric currents amplified.

The illumination produced on white paper by the light of the full moon is only one-fiftieth of a candle foot. But by the use of a sufficiently large concave mirror it could be increased to any required amount.

The televising of full-length human beings who are seen only in normal daylight, or in bright sunshine or flooded with artificial light, may be more difficult because in this method we cannot multiply the photo-electric cells. The only way to increase the photo-electric current is by enlarging the size of the concave mirror and so collecting more light.

There is, however, still room for improvement in the photo-electric cell, and research is very active in this direction. We need not, therefore, doubt that the televising of large or multiple objects will yet be achieved.

When we remember the enormous progress made in wireless telegraphy and telephony in 20 years from their inception it is not imprudent to expect that a similar great progress will be made also in the art of television.

Although the foregoing explanations are correct as far as they go, yet this description of practical television would be incomplete without some mention of the outstanding difficulties or problems to be solved before we can make any striking advance over what has been already done. The first of these is some receiver which shall be an advance on the single neon lamp so far used. There is a limit to the size of the plate which can be kept uniformly illuminated in the neon lamp by the feeble currents which are capable of being received and handled even when amplified within the limits of non-distortion.

In America they have tried making a very large neon lamp with 2,500 electrodes in it. But such a device, though practicable for a single costly experiment, worked by experts, is quite out of the question for an apparatus usable by the general public.

Then again we desire to obtain a reproduced image sufficiently bright to project by a lens on to a screen so that a considerable number of persons may see it at once. Mr. Baird is now engaged on this problem.

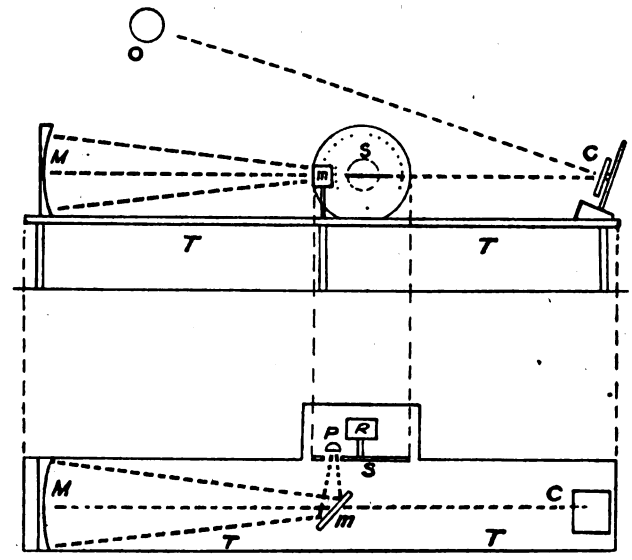

Fig. 1.—Elevation and plan views of a form of horizontal Newtonian telescope.

TT, *table*; M, *concave mirror*; m, *small plane mirror*; C, *cœlostat*; S, *scanning disk*; R, *driving motor*; P, *photo-electric cell*; O, *the moon or sun.*

If we can form a small image of a large scene such as a cricket match or football match by means of a large concave mirror or lens, but to scan that image we require also a photo-electric cell of great sensitivity because the current it is yielding at any moment is due merely to the light coming through one hole of the scanning disk, and we cannot in this case multiply or use in parallel a number of photo-electric cells. Hence, one condition for further progress is a photo-electric cell which yields a larger current per lumen than is at present obtainable. The photo-electric cell formed with cæsium deposited on oxide of silver, which has been produced by the General Electric Company, is a step in the right direction.

What we must aim at, then, is a more effective device for converting the energy of visible light into energy of an electric current, and also one for converting back again an electric current into visible light in such fashion that the light brightens and electric currents vary proportionately to each other.

We may then use a large lens or mirror to form a small but brilliant image of a large scene and scan that image, and then at the receiving end transform that varying electric current back into a luminous field which varies proportionately and is bright enough to be projected on to a screen and enlarged by a mirror or lens so as to form an image visible simultaneously to a number of people.

There is nothing impossible in these advances, and when we remember the vast improvements made step by step in wireless telegraphy and telephony in the transmitting and receiving apparatus they give good reason for anticipating similar advances in the apparatus for television in the next few years.

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Is Television in Danger?

asks SYDNEY A. MOSELEY

AN article in *Vox* by Mr. P. Wilson—"Selectivity in Excelsis"—calls for an immediate reply on my part. Indeed, if this writer's views as expressed in those columns are at all correct then I am wasting my time in proceeding with these articles on television. It is of the utmost importance, therefore, to deal immediately with the points he raises.

Referring to the *Stenode Radiostat*, the invention of Dr. Robinson, he states that he has been given "in confidence" a more complete explanation than has been generally afforded yet as to the potentialities of the Stenode Radiostat, which he further describes as the "event of the year for wireless folk." Mr. Wilson, apparently, was present at a special technical demonstration on the day before the press show, further indicating that he knows more of what the Stenode Radiostat is capable of achieving than anybody else.

For instance, Professor Appleton, the brilliant *Times* correspondent, whose capabilities are at least equal to those of Mr. P. Wilson, is not inclined to go anywhere near as far in estimating the possibilities of the new invention. Indeed it has yet to be demonstrated whether Dr. Robinson's Stenode Radiostat will affect the transmitting side of wireless at all, although from the receiving side there might be something in it. As sweeping as Mr. Wilson is in his admiration for Dr. Robinson's invention, he is equally sweeping in condemning Mr. Baird's invention:

> "But these" (demonstrations) "have only served to stimulate a desire for test experiments in which the various factors can be measured and controlled. Only in this way can one form a just estimate of the ultimate value of an invention of this kind. It is here, for example, that, in the writer's opinion, the whole case *for the Baird television system falls to the ground.*" [My italics.]

Such technical information as Mr. Baird has "condescended to disclose" does not "encourage any responsible wireless engineer to the belief or the hope that the methods hitherto employed are capable of extension or modification to produce anything more than a very crude form of television. No one is disposed to deny that television, of a primitive type, has been achieved; what we are disposed to ask is whether present methods are any more likely to produce real television than the Marconi coherer was to produce real radio-telephony. For this an invention of major importance—the thermionic valve—was necessary. Is not that precisely where television stands to-day?"

And so on.

Here I would like to stop and ask whether Mr. Wilson has paid as much attention to television as

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he has to the Stenode Radiostat. That television has been achieved even Mr. Wilson will hardly deny. If he does, let me refer him to the publicly-expressed opinions of Sir Ambrose Fleming, the inventor of the above-mentioned thermionic valve and probably the greatest living wireless technician ; and if the testimony of Sir Ambrose will not satisfy Mr. Wilson, I will refer him to the experts in Germany who have thought sufficiently well of television as an accomplished fact as to combine not with any German inventor, but with Mr. Baird, late of Helensburgh, and now of Long Acre, London.

I suppose the proof of the pudding is in the eating. Television sets are being manufactured and will be placed on the market very soon. Can Mr. Wilson make the same claim in regard to the Stenode Radiostat ?

If Dr. Robinson's claims are justified, then indeed he has achieved something of world-wide importance and he deserves our best thanks. He certainly will get mine. On the other hand one is unable to forget the similar outbursts of hyperbole prior to the broadcasting of Wireless Pictures—an experiment which unfortunately turned out so disappointingly to those who were led to believe in its immense commercial potentialities.

Dr. Robinson was adviser to Wireless Pictures, and I don't know whether he concurred in the broadcast experiments or not ; but Colonel Adrian Simpson and the Hon. Frederick Guest were associated with Wireless Pictures, and I think I am within my rights in asking those who are likely to commercialise the *Stenode Radiostat* to exercise the fullest possible care in estimating its actual capabilities before embarking on a similar experiment as was undertaken with Wireless Pictures.

So much for the Stenode Radiostat. Now I observe that Captain Eckersley has replied to my recent criticism on his attitude towards television in a weekly journal, the editor of which calls my " special attention " to what he has to say.

Captain Eckersley had evidently to go far afield to find technical backing for his opinions. He quotes Mr. Julius Winenberger, Mr. Theodore A. Smith and Mr. George Rodwin. What these gentlemen's knowledge of American television is I cannot say, but might I ask if they were aware of what British television can do ? We are all aware how far behind American television is, and it may very well be that *American* television is still nothing more than a toy.

May I remind Captain Eckersley that Professor Appleton, writing in *The Times* some months ago, stated that Baird television was so clear that it was possible even to read the time on a watch. An apparatus which can perform such a feat is surely no toy.

May I point out that Mr. Baird has demonstrated the transmission of large and small objects (I suppose a watch may be called a small object, and a boxing match a large object). No special skill is required to operate the synchronising of the British system—being a point, by the way, worthy of note, for in America they have no such thing as automatic synchronism, and depend upon manual manipulation. It is perfectly feasible, then, that American television might be classed as a toy. Anyone who has tried to synchronise manually will realise how hopeless the task is, and how impossible it is to get clear television without synchronism.

Mr. Julius Winenberger, Mr. Theodore A. Smith and Mr. George Rodwin have given their opinions of American television, but their opinion is not shared by the scientists and engineering experts who have witnessed television in London.

" In my opinion," Captain Eckersley says, " we shall need more like 1,000 k.c. before we can get service value out of television." This statement is highly misleading. What does Captain Eckersley mean by " service value " ? To use his own quotation : " The majority of dramatically interesting situations are reduced to two, or at most three persons . . . ." and it has been amply proved that these can be transmitted quite satisfactorily without the use of anything like 1,000 k.c. They have been sent through the B.B.C. stations. The statement which he quotes and which he seems to regard as authoritative is that the *minimum* requirement is 100 k.c.

In the United States, amongst other things they have not solved is the problem of automatic synchronism, and therefore a separate channel is required for the synchronising signal, which may account in some manner for this rather remarkable statement. It is quite obvious that the U.S.A. are far behind in this art.

What does Captain Eckersley want ? Does he want television to be forthwith removed from the ether because he and a few American technicians—whose names are quite unfamiliar and the value of whose testimony therefore can only be surmised—are of opinion that the B.B.C. cannot give a sufficient waveband ? Does the fact that his opinions are directly opposed to those held by technicians of considerably greater eminence than himself, and by commercial undertakings whose technical reputations are world-wide, not bid him, at least, hold his tongue and wait events, rather than attack a science which is just emerging into commercial life ?

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The Cathode-Ray Tube in Practical Television

PART III*

By *W. G. W. Mitchell*, B.Sc.

IN the February, 1929, issue of TELEVISION I gave a few details of Dr. Zworykin's cathode-ray system for television, using these words in the last paragraph of that article:—

"It is not possible at the moment to give any details as to the actual results achieved by these (*i.e.*, Dr. Zworykin's) methods. The matter is being actively pursued in the laboratory, and we shall certainly await results with the greatest interest. It remains to be seen whether the luminous intensity of the cathode ray, when projected at a potential of some 300 volts, and distributed over a large viewing surface, would be sufficiently bright to compare with the present known methods of integrating a television picture. If it does, then we shall have reached another landmark in the progress of television."

The actual achievement of practical results (either wholly or partially by cathode-ray methods) which has been eagerly awaited by many keen observers, was announced on November 18th, 1929, from New York in the following terms:—

"... Television which can be viewed by a room full of spectators rather than by one or two was announced to-day by Dr. Vladimir Zworykin, research engineer of the Westinghouse Electric and Manufacturing Company, to members of the Institute of Radio Engineers. The use of a cathode-ray tube as a receiver gives this new type of television many advantages over the well-known scanning disc method of visual broadcasting.

"The inventor is already in a position to discuss the practical possibility of flashing the images on a motion picture screen so that large audiences can receive television broadcasts of important events IMMEDIATELY AFTER A FILM of these is printed. These visual broadcasts would be synchronised with sound.

"The cathode-ray television receiver has no moving parts, making it more easily usable by the rank and file of the radio audience. It is QUIET IN OPERATION, and synchronisation of transmitter and receiver is accomplished easily, even when using a single radio channel.

"By using a fluorescent screen the persistence of the eye's vision is aided and it is possible to reduce the number of pictures shown each second without noticeable flickering. This in turn allows a greater number of scanning lines and results in the picture being produced in greater detail without increasing the width of the radio channel.

"The apparatus described by Dr. Zworykin is now being used in experimental form in the Westinghouse research laboratories in East Pittsburgh. A number of similar receivers are being constructed in order to give the set a thorough field test through station KDKA, Pittsburgh, which already is operating a daily television broadcast schedule with the scanning disc type of transmission.

"The pictures formed by the cathode-ray receiver are 4 by 5 inches in size. They can be made larger or brighter by increasing the voltage used in the receiver.

"The TRANSMITTER of this new television apparatus (Fig. 2) consists of a motion picture projector rebuilt so that the film to be broadcast passes downward at a constant speed. This film is scanned horizontally by a tiny beam of light which, after passing through the film, is focussed as a stationary spot on a photo-electric cell. The scanning motion of the beam is produced by a vibrating mirror which deflects the light from one side of the film to the other.

"Dr. Zworykin was forced to develop an entirely new type of cathode-ray tube for his *receiving apparatus* which he calls a 'kinescope.' In this tube a pencil of electrons is bombarding a screen of fluorescent material. The pencil follows the movement of the scanning light beam in the transmitter while its

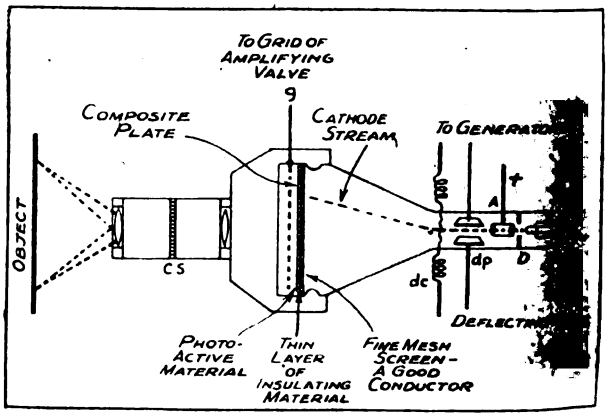

Fig. 1.—Dr. Zworykin's original transmitter.

* See TELEVISION, February, 1929; May, 1929.

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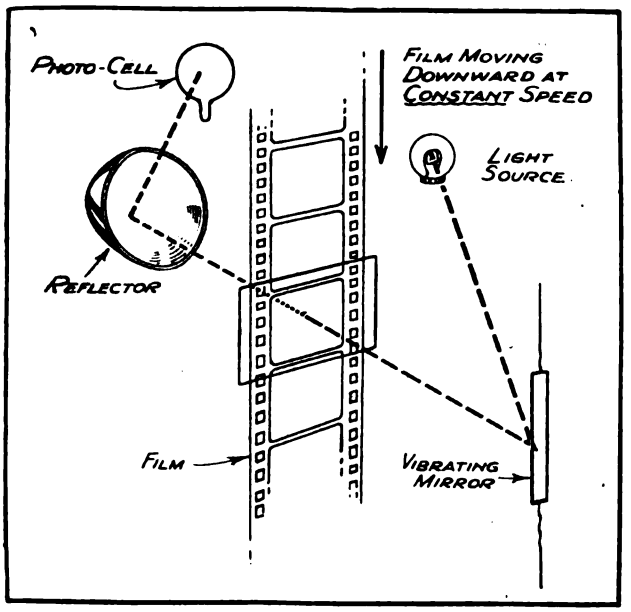
intensity is regulated by the strength of the impulses received from the transmitter. The movement of the scanning beam, consequently of the cathode-ray pencil, are so rapid that the eye receives a perfect impression of a continuous miniature motion picture.



Light modulation based on Dr. Zworykin's new scheme.

"A reflecting mirror mounted on the receiver permits the picture to be observed by a number of spectators.

"This condensed description of the methods used by Dr. Zworykin to effect television transmission can give only an idea of the possibilities of the new system. To the radio public it means, when perfected, a means of television which will be simple to operate because it has no scanning disc or other moving mechanical part. *The receiver* will operate in silence, offering no interference to sound broadcasts.

"To the radio engineer the invention is important for the same reasons and because it will not be wasteful of radio wave bands. This because the transmitter and receiver can be synchronised, using but one channel."

I have thought it desirable to give the official announcement in full if only for the reason that, in the absence of any technical details, it appears to make rather wide, if not extravagant, claims for the ease of operating a cathode-ray receiver built for television.

Scanning

Quietness of operation is, of course, a strong point in its favour, although I have not noticed that the "purr" of the motor driving a revolving disc causes unpleasantly loud noises, or is in fact audible when the loud-speaker is working. Certainly the revolving disc, motor-driven, seems an easier means of scanning than the method of deflecting the cathode-beam by applying electric or magnetic stress to the deflecting plates or coils (Fig. 3), for we have, as yet, no very definite information as to how this is to be accomplished in practice.

If we turn to the original patent specification (British Patent No. 255,057) we find provision made for two separate generators at the transmitter, assuming the use of cathode-rays. One generator (see Fig. 1) is so constructed as to generate alternating current of a frequency of about 1,000 cycles/sec., while the other is adapted to give an alternating current of a frequency at about 16 cycles. Dr. Zworykin seems to have dismissed this method for the time being in favour of a mechanical drive for the vertical component of motion of the film, and a moving light spot, operated by an oscillating mirror for the horizontal component of scanning.

But in any case the two scanning frequencies have to be separated out at the receiver. In the Patent Specification already referred to this was to be accomplished by making the oscillating circuit (*ab*) (Fig. 3) resonant to current of two distinct frequencies. By means of the H.F. transformer coupling (*b*) associated with this oscillating circuit, modulated radio-frequency currents for scanning purposes are passed to the grids of detector valves (*vp*) (*vc*) through H.F. transformer coupling (x and y), and thence to the deflecting plates (*dp*) and coils (*dc*). The pair of plates (*dp*) and the coils (*dc*) are so positioned that the magnetic field produced by the coils is parallel to the electrostatic field generated by the plates.

Modulating

The action of the cathode-ray receiver is then as follows: The received picture signals are transferred

Dr. Zworykin and his new cathode-ray tube, which he calls a "kinescope." The television images appear on the round flat end at right.

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from the oscillating circuit (*ab*) through the transformer (*n*) to the grid of the detector valve associated with this circuit, and thence to the plate and grid (*g*) of the tube. Cathode-rays are shot out from the hot cathode (*C*) under the influence of an accelerating voltage (from 300 to 4,000 volts) applied at the anode (*A*). A thin beam of these rays passes through the pinhole tubular anode, having previously been slightly deflected (and in consequence their intensity has thus been modulated) by applying the rectified picture signals to the grid (*g*) of the cathode-ray tube.

The cathode stream impinges on the fluorescent screen (*fs*), the intensity of the spot at any time being in accordance with the received picture signal and the position of the spot on the screen at any instant being in accordance with the relative actions of the deflecting plates and coils.

Sensitivity

We have no very definite information whether Dr. Zworykin's cathode-ray tube is completely evacuated or filled with an inert gas, such as argon, at very low pressure. If the latter is the case, then under average conditions, using an accelerating voltage of about 300–400 volts on the anode, a deflection of, say, 1 mm. per volt change on the deflecting plates may be expected.

The actual traverse on the screen would be about 120 mm. For a vacuum tube, if a potential difference E is applied to the deflecting plates, the stream of cathode-rays will be deflected through a distance n (in cm.) given by the relation

$$n=\frac{eE\lambda}{mv^2d}\left(L+\frac{\lambda}{2}\right)$$

Where e is the charge on an electron $= 1{\cdot}59\times10^{-20}$ (E.M.U.)

m is the mass of an electron $= 0{\cdot}9\times10^{-27}$ gm.

v is the velocity of the cathode stream

d is the distance apart of the plates

λ is the length of the plates

L is the distance travelled from the deflecting plates to the observing plane

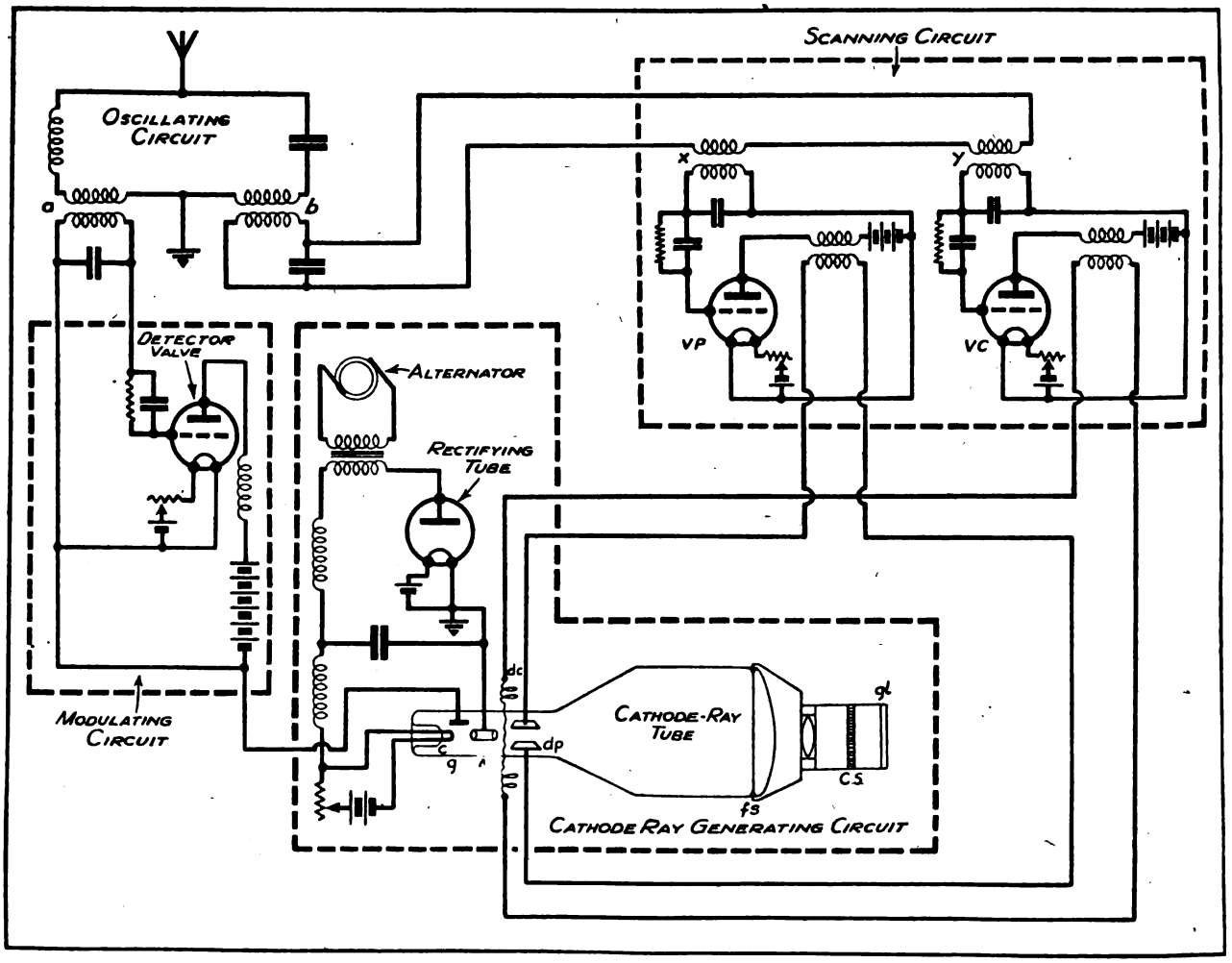

Fig. 3.—Schematic diagram of Dr. Zworykin's cathode-ray receiver.

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The *electrostatic* sensitivity of the oscillograph, *i.e.*, $\frac{n}{E}$ is therefore increased by—

(1) increasing the length of the deflecting plates;

(2) increasing the length of the path from the deflecting plates to the observing plane;

(3) decreasing the distance apart of the plates;

(4) decreasing the velocity v of the cathode-rays.

Since $v=5{\cdot}95\sqrt{V}\times 10^7$ cm./sec., the sensitivity is inversely proportional to the voltage V accelerating the cathode stream.

The *voltage* sensitivity is

$$\frac{\frac{\lambda}{d}\left(L+\frac{\lambda}{2}\right)}{2V} \text{ cm. per volt.}$$

If $V=500$ volts, and $\lambda=8$ cm., $L=20$ cm., $d=0{\cdot}5$ cm., then the sensitivity is 0·38 cm. per volt or 2·6 volts per cm. deflection. Increasing the voltage V to 2,000 will reduce the sensitivity to one-quarter of that when $V=500$ volts. So that to obtain increased sensitivity low accelerating potentials must be used. But by reducing V, we reduce also v, the velocity of the cathode stream and consequently the penetrating power of the rays is correspondingly decreased.

Cost

One very serious difficulty (perhaps the main difficulty) is to produce in practice with anything like regularity an intensely bright concentrated point on the fluorescent screen. The pinhole tube of the anode may be of extremely small bore, nevertheless the beam will tend to "spread." Striction coils wound round the axis of the tube simply tend to set up a spiral motion in the cathode stream itself, and only add to the complications of the apparatus.

In former articles I have stressed the comparatively short useful life of the ordinary low-pressure gas-filled, hot filament type of tube, which is probably due to the back-bombardment of the cathode by heavy argon atoms. In a recent form of cathode-ray oscillograph, described by Dr. A. B. Wood (*Inst. Elec. Eng. Journal*, 63, page 1046, 1925; and *Proc. Phys. Soc.*, Vol. 35, page 109, 1923), and of the vacuum type, the different parts of the tube are made demountable. This form of tube certainly possesses many advantages over the ordinary commercial type, *e.g.*, the deflecting plates can be adjusted and altered at will, and the filament can be renewed quite simply. A very accurate fit of the ground glass joints is indispensable, and a continuous vacuum must be maintained by pump action. Provision must also be made for a D.C. generator to give the 3,000 or 4,000 volts required for the anode potential.

"A Laboratory Instrument"

The oscillograph we find listed at £120, or with accessories (mercury vapour pump or high vacuum pump with motor and high-tension D.C. motor generator equipment) about £100 extra, which places such an equipment outside the range of practical television. The results given are indeed excellent, but the instrument in its present form is essentially a laboratory instrument, requiring skill and patience in its operation.

It should perhaps have been mentioned that the original scheme given in Patent Specification 255,057 was ambitious, as provision was made for colour television by means of a three-colour screen of the "Paget" type (*cs*) (Fig. 3), the natural colour effect being viewed through a ground-glass screen (*gl*). But my intention in this article has been to examine

Photograph of Zworykin's new cathode-ray television receiver. The images are projected on to a mirror on the top of the cabinet, thus making it possible for a number of people to watch at once.

critically, as far as it is possible in the light of published information, the merits of the cathode-ray system for television purposes.

The outstanding difficulty still seems to me to be able to secure an intensely bright and concentrated spot on the fluorescent screen with ordinary voltages of, say, 300 volts anode potential, added to which is the present high cost of tubes and auxiliary apparatus. But it is to be hoped that before long we may have a chance of examining Dr. Zworykin's apparatus under working conditions in this country, and perhaps then I shall be able to revise my remarks in the opening paragraph of this article in the light of practical achievement.

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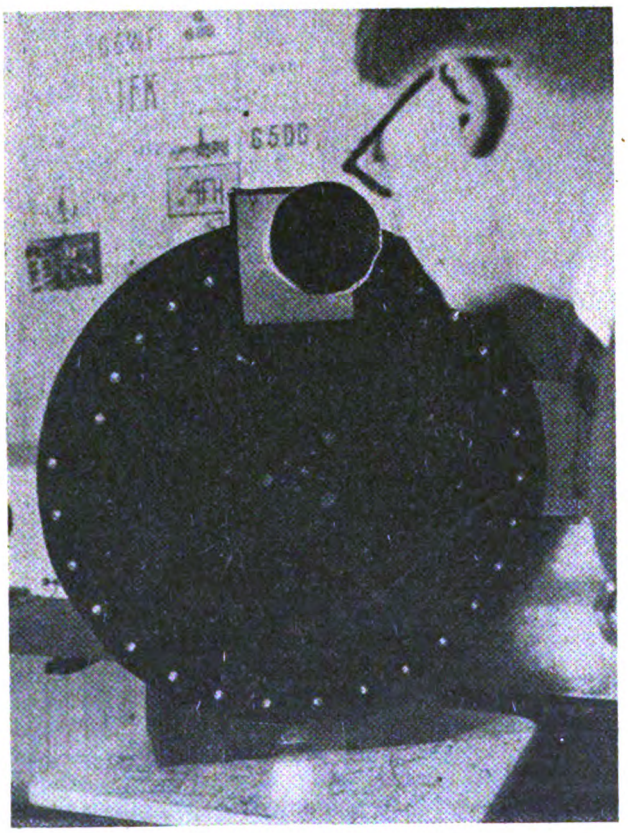
How Amateurs are Receiving the Television Broadcasts

THE television critics and pessimists have been asking "What use are the amateurs making of television transmissions?" and answering for themselves "Nothing." But to judge from letters received the amateurs, as fast as they can get apparatus made, *are* making use of the transmissions. This, no doubt, is somewhat disconcerting for the critics and pessimists, but very gratifying to those who have fought for broadcast transmissions.

As far as the morning transmissions are concerned very few amateurs seem to have been able to "look-in," but even so, several reports have been received from places as far away as Weymouth. One amateur from Broadstairs took the trouble to come up to London to enquire, and, walking into the Baird Laboratories, singled out one of the staff as the man he had seen by television.

It was not, however, until the evening transmissions started that the majority of amateurs had a chance to do very much, but that they were all waiting for a more favourable transmission time is now evident. The record for long distance reception is at present held by Mr. H. Hewel, of Berlin.



Mr. H. Hewel, of Berlin, looking into his Televisor.

Writing on Jan. 4th he says: "I heartily congratulate you to the fine development of television. The images I received were not much worse than those I saw with my apparatus in June, 1929, when you made experimental television over our local Witzleben transmitter and *better than our German Radio-Movies.*" As Mr. Hewel's letter was in English his words have been given unaltered.

Following the paragraph already quoted, he goes on to say that in the tele-reading, which formed part of the transmission, he read the words "Carmen, who will appear at the next television concert," and adds that as he had got his motor and disc set up backwards everything was reversed, and he found it a little difficult to read the letters backwards! All the same, he read them aright, and as his only means of synchronising at present is by running his motor a little fast and then pressing his finger on the spindle to slow it, he could scarcely be expected to retain synchronism by such crude means long enough to read the whole bulletin.

He did, however, see and recognise one of the staff as a person who was televised in Berlin, and correctly describes his movements.

He uses a superhet. receiver driven from the D.C. mains, with four pentodes in the last stage. The neon tube is his own construction fed by a circuit arrangement, also his own, and taking about 25 m.a. His motor is a D.C. instrument fed from 220 v. mains, but as his scanning disc is the standard German one with a picture ratio of 3 to 4, his images were somewhat compressed and distorted in a vertical direction. He is making a new disc with the right picture ratio, and concludes his letter by asking the times of the evening transmissions.

In a later letter Mr. Hewel reported that he had reversed his disc and motor to receive things the right way round, and gives a correct programme of the January 6th evening transmission of television. This was received without the aid of a correct synchronising device, his finger used as a brake on the motor spindle still being used.

By the following Friday, January 10th, a correctly proportioned disc was constructed, and writing of this reception he says: "I was sitting before the

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televisor surrounded by seven people eagerly looking in. After a few moments speed was correct and he (meaning one of the subjects) was to be seen. The picture was O.K.! (*and the seven heads banging together!*). The suspicious were astonished at the quality of the pictures; they could even see the convolutions of the ear of the subject. The face of the televised doll and the hand moving it were at once recognised. Statics very often destroyed the image. In spite of this fact the demonstration was a great success."

The telereading was read by three of Mr. Hewel's friends—the others did not understand English.

Dr. F. Banneitz, technical director of the R.P.Z. and editor of *Fernsehen* (the German television paper), rang Mr. Hewel up on the Saturday following this reception, and while discussing it with him admitted that he had seen nothing like letters. Mr. Hewel adds, "with the big apparatus behind him!" and goes on to explain that the secret of his own success is due to the variably coupled intermediate frequency band pass filters in the set he uses. His set has only two dials and a rheostat for tuning.

It would seem that Germany possesses the same type of experts as England, for Mr. Hewel remarks that his experience contradicts an article in *Fernsehen* which states "a good television reception over distances of hundreds of miles is possible only with such complicated apparatus that no layman can tune it, if reception is possible at all."

His experience but further proves what amateurs all over the world have known for a long time; experts are all right when they are treading beaten paths, but when they express opinions on new work they become mere children beside the experienced amateur.

TELEVISION sends Mr. Hewel hearty congratulations on his success. His work is more valuable than the pious opinions of all the experts.

The next longest distance report of reception comes from Rotterdam, where Mr. M. W. H. de Gorter utilised Boxing Day morning to tune in to London. It was his first chance to listen to a television transmission. He, as yet, has no "televisor," but he reports that on a three-valve set he got signals more than loud enough to work a loud-speaker and, using the neon tube from his wave-meter, he was able to employ the signal to cause the lamp to flicker. He is getting very busy about an experimental "televisor," and as he is a capable experimenter and short-wave enthusiast he should be getting results before very long.

Coming to England, Mr. A. E. Kay, of Waterloo Street, Lower Crumpsall, Manchester, holds the long distance record for this country. His set is a screen grid, detector, and two L.F. with one valve resistance capacity and the output push-pull with 350 volts H.T. Being unable to get a suitable neon, he is using an Osglim with the resistance in the cap. The whole of his apparatus is home-made and he says he has been very successful.

In a second letter he gives more details of what he has been able to see and describes one of the young ladies who was transmitted, with considerable and accurate detail. So far, he has had no synchronising device in use but is busy building one and hopes to have it in operation soon. His receptions have been seen by many folk in the district and he says all have been surprised and delighted at the results he is getting.

Mr. Colin P. Garside, of "Two Gates," Maidenhead Court, Maidenhead, a member of the "Television Society," seems from his letters to have had the most consistent reception, for apparently he has missed very few of the transmissions, morning or evening. The whole of his apparatus is home-made and mains driven, in this case, D.C., 230 volts. He is using anode bend detection and three stages of R.C. with two valves in parallel in the last stage. His neon is choke fed and he uses an Osglim flat plate type. His synchronising gear is of the Baird type fed through a special valve, transformer coupled to the picture output. He started reception with leaky grid detection but changed over to anode bend, and now says "During the last few weeks images have been really good. . . ."

"The lettering (he refers to the news bulletin which forms a part of most transmissions) "of course, comes through perfectly."

In a later letter, the detail in the image is referred to as being "surprising."

Another amateur using home-made apparatus, synchronising device, etc., is Mr. A. R. Knipe, of Southsea Avenue, Leigh-on-Sea.* He employs two stages of R.C. with two valves in parallel in the output stage and 230 volts H.T. and says he receives an image which is "quite easily recognisable."

For sheer hard work and enthusiasm, the report of Mr. F. Austen, of Church Street, St. Peters, Broadstairs, would be hard to beat. He has a set developed largely from his experience of public address systems, in which he is interested, and uses a screen grid, anode detection, two stages of R.C. with push-pull for the output. Before television transmissions began he was experimenting, but on the day of the first broadcast he rose early, took a sheet of 1/8 galvanised iron, marked it out, drilled and countersunk the holes, and by 11 o'clock had it mounted and had some sort of reception.

During the day work suffered, for he was thinking scanning discs. That evening, or night rather, he put the result of his meditations into practice and on the next day was successful in his reception. He has no synchronising gear but has a particularly well-made ball-bearing motor run off accumulators. It runs so steadily that a variable resistance in the field has so far met his synchronising requirements. Discs have been his great trouble and he has made a number but is now on the right track with one made of thin aluminium sheet. He it was who visited the Baird Laboratories and made the somewhat startling declaration to one of the staff: "I saw you by television yesterday."

As a result of his experiments he has thoroughly stirred up local enthusiasm for television reception and has usually a queue of folk waiting to "look-in" when anything is on.

W. C. F.

*See our January issue for details of Mr. Knipe's apparatus.

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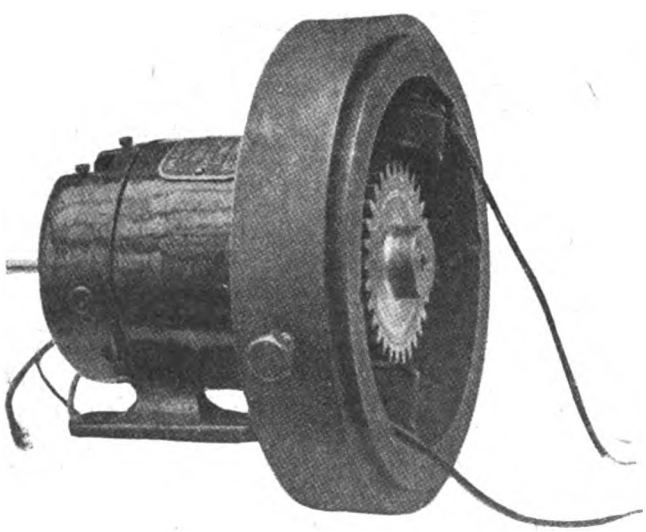
Experimental Television Apparatus

By *A. A. Waters*

PART IX

IN the preceding article of this series a detailed description was given of a phonic wheel type of synchronising device, together with complete constructional data. The apparatus described is somewhat similar to that used in the television receivers now being manufactured by the Baird Company, and is intended for use when receiving the television transmissions from 2LO. In view of the considerable interest at present being shown in the technical Press in the practicability of this system of synchronisation, and as an assistance to those experimenters who have constructed synchronising devices on these lines, I propose to devote this article to a description of the experimental results obtained from the apparatus, together with a brief technical review of the problems involved, and a few suggestions for the improvement of the construction already described.

Before commencing experiments with a phonic wheel synchroniser the experimenter should realise that he is actually using a simple form of alternating current synchronous motor. When the field coils of the phonic wheel are supplied with alternating current,



General view of the driving motor, showing how synchronising gear is attached.

of frequency n cycles per second, the wheel will tend to rotate at a speed given by the expression:—

$$\text{Synchronous speed (r.p.m.)} = \frac{60 \times n}{N} \times 2,$$

where N is the number of teeth in the wheel.

It must be realised, however, that this effect will not be produced unless the phonic wheel is first rotated by some external means at the correct synchronous speed, after which it will tend to continue rotating at this speed; and if the apparatus is well designed, and supplied with sufficient current, the wheel should run as a motor and develop appreciable power.

The reason for this is easily seen. The field magnets will exert a magnetic pull during each half-cycle of the alternating current. Actually the polarity of these magnetic impulses will be alternately reversed, since the positive and negative half-cycles will respectively magnetise the field magnet cores in opposite polarity.

If we assume, however, that the wheel itself is of soft iron, and is not permanently magnetised, it will become magnetised during each magnetic impulse by the process of magnetic induction. Thus the particular tooth of the wheel which happens to be nearest to one of the field poles during a particular half-cycle of the A.C. supply will be automatically magnetised in the reverse polarity to that pole, and hence will be attracted towards it. This will always occur, whatever polarity the field poles may be. When the phonic wheel is rotating at synchronous speed, a tooth will be approaching each field pole at the moment of maximum pull, and will be attracted by it. As this tooth passes the pole, the magnetic pull will have fallen to the low value which occurs between each half-cycle of the A.C. supply. The tooth can thus pass away from the pole without any appreciable magnetic pull to retard its progress, and the next tooth will be approaching the pole in time to be attracted towards it by the magnetic pull caused by the next half-cycle. Thus at the synchronous speed only, these pulls of the field poles on successive teeth are cumulative, and produce a rotation of the wheel. At other speeds the magnetic impulses are not so co-ordinated and no resulting pull on the wheel as a whole will be experienced.

An attempt to make this action clear is shown in

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Fig. 1, in which a few teeth of the phonic wheel are indicated in the position which they would occupy during rotation at a moment of maximum magnetic attraction.

It is interesting to note that a tendency to rotation

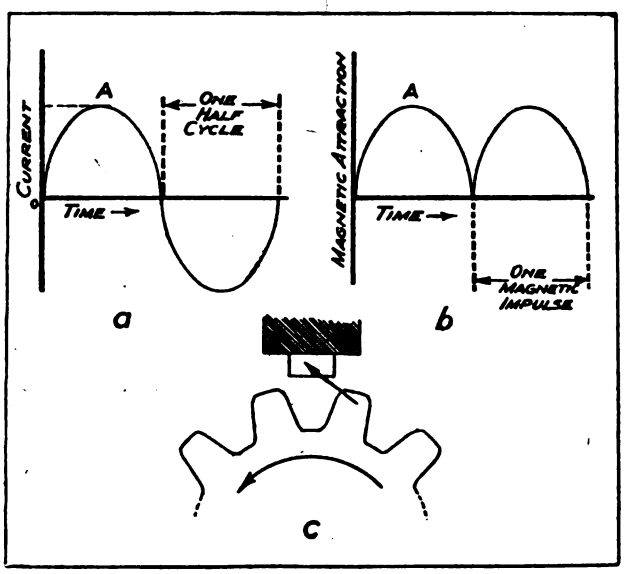

Fig. 1.—Illustrating the action of a phonic wheel. (a) *Curve showing A.C. through field coils.* (b) *Curve showing corresponding magnetic attraction of poles (neglecting effect of hysteresis.* (c) *Showing position of a tooth at time corresponding to* (a).

can exist at speeds other than the synchronous speed, but which are harmonically related to it. The power developed under these conditions, however, is usually very small.

The conditions of operation described in the foregoing remarks have certain disadvantages. The direction of magnetisation of the iron which composes the wheel and poles is being continually and rapidly reversed. Owing to the effect of magnetic hysteresis and magnetic lag, the intensity of magnetisation of the iron will never reach the value which it could attain if the direction of magnetisation were always the same. This effect becomes very serious when attempts are made to run the phonic wheel from alternating current of high frequency, and increases considerably as the frequency is increased. It has the effect of reducing the efficiency of the device very appreciably.

The performance of the wheel is greatly improved if the field coils are excited by direct current in addition to the alternating current which drives it. In this case the magnetic impulses are superimposed upon a steady magnetic pull. If the steady magnetisation is greater than that due to the A.C. impulses, which can be assured if the direct magnetising current is more than twice the peak value of the alternating current, then all magnetic impulses will be of the same polarity. There will then be one magnetic impulse for each cycle of the alternating current, and this will be due to a change of current which is double that in the previous instance. Moreover, it can easily be shown mathematically that the magnetic pull per impulse is greatly increased when the current fluctuations are superimposed upon a strong pre-existing field.

It is for this reason that a strong permanent magnetic field is always used in the case of telephones, loudspeakers, and other apparatus which operates by virtue of magnetic attractions and repulsions. The state of affairs existing in this case is indicated in Fig. 2. It is important to note that the synchronous speed in this case is only half what it would be if the phonic wheel be operated from alternating current only; or, alternatively, only half the number of teeth are required to give a particular synchronous speed. This is because there is now only one magnetic impulse per cycle, as compared with two impulses in the first-mentioned case. The expression for the synchronous speed now becomes:—

$$\text{Speed (r.p.m.)} = \frac{60 \times n}{N}$$

Consider now the case of the Baird television transmissions. We wish to operate the phonic wheel from the "line frequency" which is a prominent component of the television signal, and is given by the product of the number of pictures transmitted per second and the number of holes used in the scanning discs. This will be $12{\cdot}5 \times 30 = 375$ ~/sec. Hence we can work out the number of teeth required if the wheel is to drive our disc at the picture speed of 12·5 revolutions per second. If the field is fed from pure alternating current, at 375 ~/sec., we have:—

$$\text{Speed} = 12{\cdot}5 \text{ r.p.s.} = 2\frac{375}{N} \therefore N = 2\frac{375}{12{\cdot}5} = 60 \text{ teeth.}$$

Or if the field coils also carry direct current:—

$$\text{Speed} = 12{\cdot}5 \text{ r.p.s.} = \frac{375}{N} \therefore N = \frac{375}{12{\cdot}5} = 30 \text{ teeth.}$$

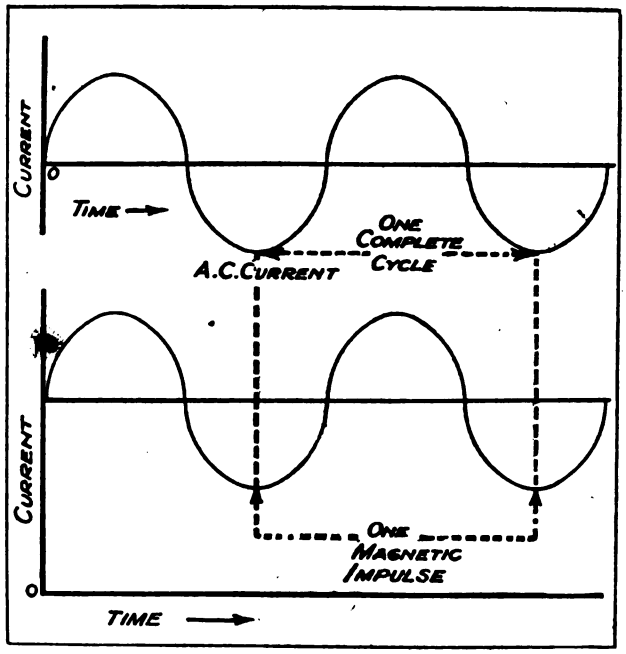

Fig. 2.—Showing the relation between current and magnetic impulse.

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Thus it becomes clear that when a 30-tooth phonic wheel is used to synchronise the receiving disc on the Baird transmissions the field coils must be excited

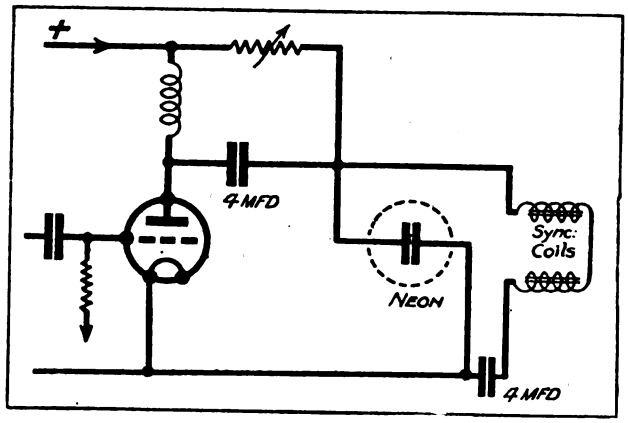

Fig 3.—" No results of consequence could be expected from a circuit such as that shown above."

with direct current. No results of consequence could be expected from a circuit such as that shown in Fig. 3, in which these coils are fed with the " line frequency " only through the medium of a choke and condenser filter; and it is easy to understand why results cannot be obtained by experimenters who have made the elementary mistake of using this arrangement in conjunction with a 30-tooth wheel, or its equivalent. A 60-tooth wheel is necessary to give success with this circuit, although in any case the synchronising effect may be expected to be poor. In our own case, and using the phonic wheel described in our last article, no synchronising effect at all could be observed.

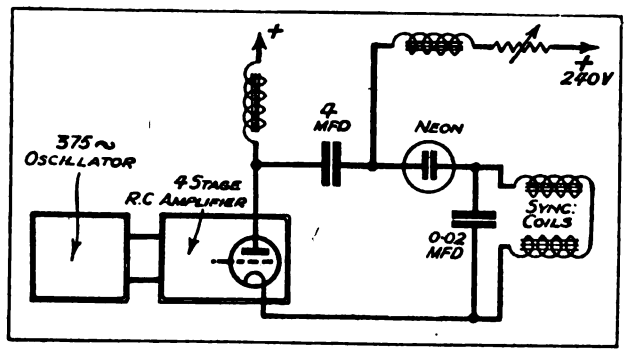

Fig. 4.—By connecting the synchronising coils in series with the neon tube definite results will be obtained.

As far as the writer is aware, the circuit used by the Baird Company in their standard receivers is substantially that given in these articles last month, the field coils of the synchroniser being connected in series with the neon tube. Thus the steady current used to illuminate the neon tube, which may be about 20 milliamps for an average commercial tube, will flow through these coils, and will produce the necessary magnetic field.

Since the variation of current through the neon tube is unlikely to be more than 5 or 10 milliamps, the condition in which the steady current exceeds the alternating current peak value is also achieved.

In order to check the performance of the phonic wheel unit, an artificial source of signals was arranged, consisting of a suitable oscillator of approximately 375 ~/sec. frequency, supplying a four-stage television amplifier. Two B.T.H. power valves, type PX650, were used in parallel in the output stage of this amplifier, the high tension voltage used being approximately 240 volts. The signal strength given to the neon tube and synchroniser connected in series, as in Fig. 4, was increased until the anode current milliameter in the power stage indicated the beginnings of overload, and the direct current motor driving the receiving disc was run up until stationary horizontal dark bands indicated that synchronous speed had been attained. A quite definite effect due to the phonic wheel could be detected, there being a tendency for these dark bands to rock gently up and down instead of rotating slowly as is usually the case when no synchronising system is in use. It was necessary, however, to keep the D.C. motor carefully adjusted, the controlling effect of the phonic wheel not being very powerful.

Consideration will show that the impedance of the field coils of the synchronising device is an important factor in its efficient operation. The impedance of a glowing neon tube may be taken as sensibly equal to its D.C. resistance, which is of the order of 9,000 ohms, and hence if one-half of the available energy is to be used for synchronisation, the impedance of the field coils would have to be of the same order.

Approximate calculation indicated that the impedance of the coils in use when mounted in position, and wound with 36 S.W.G. D.C.C. wire, which was originally chosen from considerations of mechanical strength, would be unlikely to exceed 300 ohms, and hence these windings were unsuitable for direct connection into the neon tube circuit. Hence the circuit shown in Fig. 5 was evolved. The coils were supplied from a 20/1 ratio transformer, of a type intended for use with low resistance moving coil loudspeakers. The step-up of current thus obtained was expected to operate the coils more efficiently, their effective impedance being now raised to the correct order. The magnetising current was now obtained

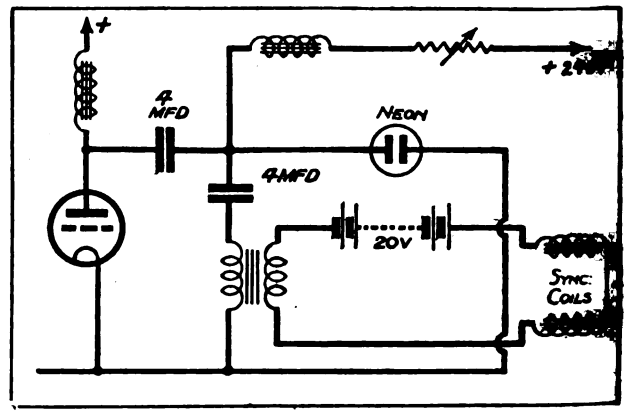

Fig. 5.—A transformer coupled circuit.

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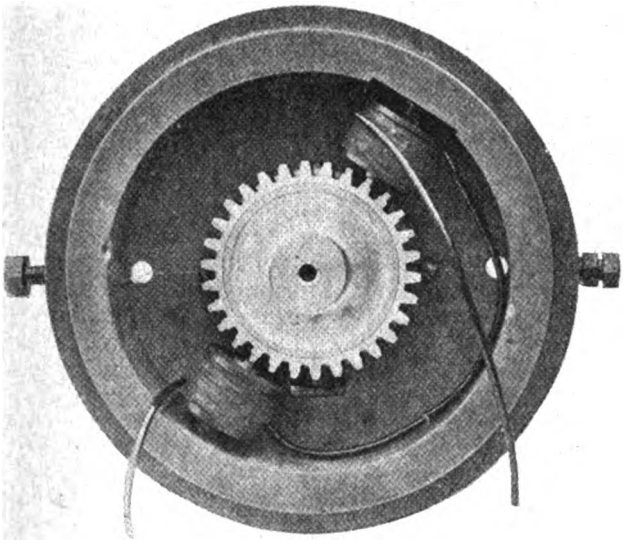
from a 20-volt battery of accumulators placed in series with the transformer secondary and the field windings. A current of 1 ampere then flowed in this circuit, and the strength of field thus obtained was sufficiently great that the pull of individual teeth



An end view of the synchronising gear. These photographs should be studied in conjunction with the instructions and drawings given by our contributor in our January issue.

could be very easily felt on rotating the scanning disc slowly by hand.

On repeating the synchronising test, very promising results were obtained, the scanning disc remaining in synchronism for considerable periods. Provided that the D.C. motor is running very steadily, the image remains framed for periods which may reach several minutes; and the result may reasonably be described as satisfactory. It should be unnecessary to emphasise at this stage that success depends very largely on the quality of the D.C. motor used, and the steadiness of the supply from which it is being run. The power developed by the phonic wheel is not sufficient to control any very pronounced variation of motor speed.

As a further experiment, the field coils were removed, and re-wound with 8,000 turns each of 40 S.W.G. S.S.C. copper wire, which was estimated to raise their impedance to about 5,000 ohms at 375 cycles/sec. The resistance of each coil was then 3,500 ohms. The circuit of Fig. 4 was then tried again, and gave very similar results to those obtained when using the transformer and lower impedance coils. Hence this winding can be recommended to those who prefer not to use a transformer.

It was now thought that the time had come to test the arrangement on the morning television transmissions. Therefore, the input to the four-stage R.C. coupled amplifier was transferred from the oscillator to the output of a radio receiver comprising and H.F. and detector stage. Television reception was obtained in the usual way, but owing to the high impedance of the field coils preventing the higher frequencies from reaching the neon tube, it was found essential to shunt these coils by a condenser before good definition of the image could be obtained. A capacity 0·02μF proved suitable.

We were pleased to observe a definite synchronising effect, which was of considerable assistance in holding the image in view. In the ordinary course of events it was not found possible to dispense entirely with the hand control, although on a few occasions when the receiving motor was kindly disposed, the image rocked gently in view without adjustment for some time, in one case for as long as three minutes.

In view of these results it can definitely be stated that a simple phonic wheel, as described in the preceding article of this series, will give a useful degree of synchronisation when properly handled. It must be remembered that its construction is by no means perfect, and that with a more advanced design the results might approach much nearer to perfection.

For example, the use of an ordinary cast-iron gear wheel for the phonic wheel, and of a cast-iron outer casing, is not a good practice, and can only be justified from the point of view of cheapness and availability. Those who are prepared to have these parts constructed from soft iron, mild steel, or one of the new high magnetic permeability steels which are now in use for transformer cores, etc., may expect an increase of at least threefold in the power developed by the phonic wheel. An increase in the number of field poles to four and the use of a more ambitious power amplifier are other improvements which the keen experimenter might like to incorporate in his designs.

Owing to the fact that the present television transmissions consist so largely of head and shoulders reproductions, and seldom show rapid motion or sudden change of scene, it is not possible to give an opinion as to whether this would throw out the synchronising effect.

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The "Wave Band" Theory of Wireless Transmission*

By *Sir Ambrose Fleming*, F.R.S.

IN scientific history we meet with many examples of scientific theories or explanations which have been widely adopted and employed, not because they can be proved to be true but because they provide a simple, easily grasped, plausible explanation of certain scientific phenomena. The majority of persons are not able to see their way through complicated phenomena and so thankfully adopt any short-cut to a supposed comprehension of them without objection.

Ease of comprehension is not, however, a primary quality of Nature, and it does not follow that because we can imagine a mechanism capable of explaining some natural phenomenon it is therefore accomplished in that way. There is a widely diffused belief in a certain theory of wireless telephonic transmission, and also of television, that for securing good effects it is necessary to restrict or include operations within a certain width of "wave band." But although this view has been very much adopted there is good reason to think that it is merely a kind of mathematical fiction and does not correspond to any reality in Nature.

Let us consider how it has arisen. We send out from all wireless telephone transmitters an electromagnetic radiation of a certain definite and constant frequency expressed in kilocycles. Thus 2LO London broadcasts on 842 kilocycles. This means that it sends out 842,000 electric vibrations or waves per second. Every broadcasting station has allotted to it a certain frequency of oscillation and it is not allowed to depart from it.

It is like a lighthouse which sends out rays of light of one pure colour or an organ which emits a single pure musical note. For most broadcasting stations this peculiar and individual frequency lies somewhere between a million and half a million per second, though for the long wave stations like Daventry it is so low as 193,000 or 193 kilocycles.

When we speak or sing or cause music to affect the microphone at a broadcasting studio the result is to cause the emitted vibrations, which are called the *carrier waves*, to fluctuate in height or wave amplitude, but does not alter the number of waves sent out per second. It is like altering the height or size of the waves on the surface of the sea without altering the distance from crest to crest which is called the wavelength.

Suppose the broadcasting station emits a carrier wave of frequency n and let $p=2\pi n$. Then we may express the amplitude a of this wave at any time t by the function $a=A \sin pt$ where A is the maximum amplitude. If on this we impose a low frequency oscillation due to a musical note of frequency m and let $2\pi m=q$, then we can express the modulated vibration by the function

$$a=A \cos qt \sin pt.$$

But by a well-known trigonometrical theorem this is equal to

$$\frac{A}{2}\left\{\sin (p+q)t+\sin (p-q)t\right\}$$

and thence may be supposed to be equivalent to the simultaneous emission of two carrier waves of frequency $n+m$ and $n-m$.

If the imposed note or acoustic vibration is very complex in form, then in virtue of Fourier's theorem it may be resolved into the sum of a number of simple harmonic terms of form $\cos qt$, and each of these may be considered to be equivalent to a pair of co-existent carrier waves. Hence the complex modulation of a single frequency carrier wave might be imitated by the emission of a whole spectrum or multitude of simultaneous carrier waves of frequencies ranging between the limits $n+N$ and $n-N$, where n is the fundamental carrier frequency and N is the maximum acoustic frequency occurring and $2N$ is the width of the wave band. This, however, is a purely mathematical analysis, and this band of multiple frequencies does not exist, but only a carrier wave of one single frequency which is modulated in amplitude regularly or irregularly.

If the sounds made to the microphone at the broadcasting station are very complex, such as those due to instrumental music or speech, then in virtue of this mathematical theorem the very irregular fluctuations in amplitude of the single carrier wave can be imitated if we suppose the station to send out simultaneously a vast number of carrier waves of various frequencies lying between certain limits called the "width of the wave band."

This, however, is merely a mathematical artifice similar to that employed when we resolve a single force or velocity in imagination into two or more component forces. Thus, if we consider a ball rolling down an inclined plane and desire to know how far it will roll in one second, we can resolve the single vertical gravitational force on the ball into two

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components, one along the plane and one perpendicular to it. But this is merely an ideal division for convenience of solution of the problem; the actual force is one single force acting vertically downwards. Similar reasoning is true with regard to wireless telephony. What happens, as a matter of fact, is that the carrier wave of one single constant frequency suffers a variation in amplitude according to a certain regular or irregular law. There are no multiple wavelengths or wave bands at all.

The receiver absorbs this radiation of fluctuating amplitude and causes the direct current through the loud speaker to vary in accordance with the fluctuations of amplitude of the carrier wave; the carrier wave vibrations being rectified by the detector valve.

The same thing takes place in the case of wireless transmission in television. The scanning spot passes over the object and the reflected light falls on the photoelectric cells and creates in them a direct current which varies exactly in proportion to the intensity of the reflected light. This photoelectric current is employed to modulate the amplitude of a carrier wave, and the neon lamp at the receiving end translates back these variations of carrier wave amplitude into variations in the cathode light of the neon tube.

There is neither in wireless telephony nor in television any question of various bands of wavelength. There is nothing but a carrier wave of one single frequency which experiences change of amplitude. The whole question at issue then is: What range in amplitude is admissible?

In the case of television it is usual for critics of present achievements to say that good or satisfactory television cannot be achieved within the limits of the nine kilocycle band allowed. But there is in reality no wave band involved at all. It is merely a question of what change in amplitude in a given carrier wave can be permitted without creating a nuisance.

It is something like the question: How loud can you whisper to your next neighbour at a concert or theatre without being considered to be a nuisance? People do whisper in this way and, provided not too loudly, it is passed over. But if anyone is so ill-mannered as to speak too loudly he is quickly called to order, or turned out.

It is, however, not an easy thing to define a limit to wave amplitudes. They are measured in microvolts per metre and are difficult to measure. But a wavelength is easy to define in kilocycles or in metres, and hence the method has been adopted of limiting emission to an imaginary band of wavelengths which, however, do not exist.

The definition is imperfect or elusive. It is something like the old-fashioned definition of metaphysics as "a blind man in a dark room groping for a black cat which isn't there." Similarly, the supposed wave band is not there. All that is there is a change, gradual or sudden, in the amplitude of the carrier wave. It is clear, then, that sooner or later we shall have to modify our code of wireless laws.

We have no reason for limiting the output of our broadcasting stations to some imaginary wave band of a certain width, say nine kilocycles or whatever may be the limiting width, but we have reason for limiting the range of amplitude of the carrier waves sent out.

Some easily applied method will have to be found of defining and measuring the maximum permissible amplitude of the carrier waves as affected by the microphone or other variational appliance. It may perhaps be thought that an unnecessary fuss is here being made on what may be regarded as simply a way of explaining things, but experience in other arts shows how invention may be greatly retarded by unessential official restrictions. Consider, for example, the manner in which mechanical traction was retarded in Great Britain for years by ridiculous regulations limiting the speed of such vehicles on highway roads. The only restrictions that should be imposed are those absolutely necessary in the interests of public safety or convenience, and all else tend to throttle and retard invention and progress.

[Since the above article was published in *Nature*, of January 18th, the author has extended his argument as follows, with special reference to the case of television.—Editor of TELEVISION.]

The futility and obstructiveness of this wave-band theory, especially as regards the transmission of television images, may best be seen by the following manner of regarding the facts. It has been shown above that when a single carrier wave of fixed high frequency electro-magnetic radiation is sent out as from a broadcasting station, and when this wave is modulated by super-imposing on it a low-frequency oscillation, the result is to produce a wave which varies periodically in amplitude or has *beats* on it, but which retains the carrier-wave frequency.

In virtue of the mathematical theorem explained above this actual modulated wave may be regarded as due to the sum of two fictitious or imaginary carrier waves of frequencies respectively equal to the sum and the difference of the frequencies of the actual carrier wave and the super-imposed low-frequency oscillation.

Thus, suppose the 2LO station to send out a carried wave of 842 kilocycles, the regulation is that the wave-band due to modulation must not be more than 9 kilocycles wide: that means the imaginary components must have frequencies lying within the limits 842,000+4,500 and 842,000−4,500.

This implies that the carrier wave of 842 kilocycles must not have more than 9,000 *beats*, to use the musical term, or increases of amplitude on it per second of time. But the possibility of disturbance to other receivers depends not upon the number of the beats per second but upon their amplitude, and it is futile to put restrictions upon the number of fluctuations of amplitude per second whilst ignoring the effect of any excessive amplitude.

In television this operates injuriously because it compels a certain degree of coarseness in the image. To obtain good television reproduction, no hindrance

(*Continued on page* 604.)

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Television for the Beginner

PART II

By *John W. Woodford*

IN introducing our subject last month we saw that in any television process no *actual light* is transmitted but merely an electrical replica. This is important, for there are some people who seem to regard television as being something in the nature of a magic field glass which is going to destroy all privacy. This is just as far from the truth as imagining a delicate earpiece with which it is possible to listen to any sound no matter from where that sound emanates. Since a process of conversion has to take place it must only be possible to show scenes or objects which come within the range of the mechanism used to transmit them. Of course developments will continue to be made whereby the scope of the subject will be increased, but at the moment we are concerned with things as they are and not what they will be.

Broadcasting Television

I gave my reasons for intending to deal with the Baird process in detail, although the different television systems which are engaging the attention of scientists all over the world have certain points in common, but before going into any detailed explanation of the apparatus I will confine my remarks to generalities.

The process of broadcasting television may be best explained by stating that, first of all, the scene, object, person or persons in front of the transmitting apparatus are, in effect, turned into minute electric currents. These can be heard as sound in a pair of headphones, and each scene has its corresponding sound. An experienced television engineer can even go so far as to recognise outstanding objects by their image sounds. For example, a hand held in front of the transmitter causes a somewhat harsh rattling note, whereas a face gives a softer note without any suggestion of rattling.

Some of the Apparatus

A special optical apparatus is placed in front of the televised object. Essentially this consists of a rapidly revolving metal disc with a powerful source of light housed in a chamber with a truncated funnel placed behind it, somewhat as indicated in Fig. 1. Equally spaced around the disc and located near the edge is a spiral of tiny holes as shown. Now as each hole passes before the intense light area at the end of the funnel it will permit a ray of light to pass through the hole and move upwards.

As soon as one hole has finished its travel in front of the light and caused the ray of light to trace a vertical strip on a screen situated a few feet away from the disc, so another hole performs the same operation. But since each hole is situated a little nearer to the centre of the disc than its predecessor, each ray of light passes over a different strip area until all the holes have passed round. The process then begins all over again.

Narrow Light Strips

Now what effect is produced by this simple piece of apparatus? That is, the fixed source of light and the rotating disc perforated with holes. Why, if a person sits between the disc and the screen, his or her features will really be sub-divided up into a number of narrow light strips. Every part of the face is therefore successively illuminated by a small point of light, the ultimate result being to break up the features into a series of strips next to one another. An idea of what is meant will be gathered by examining Fig. 2, which shows the head and shoulders of a person located within the area of light traversed on the back screen.

Each revolution of the disc causes a repetition of this process, and the rapidity of the repetitions is plainly dependent upon the speed with which the perforated disc rotates.

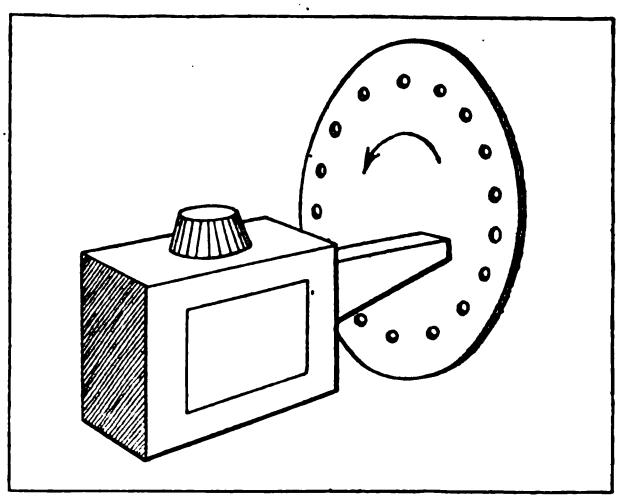

Fig. 1.—The essential mechanism of a Television Transmitter.

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Reflecting Light

It is fairly well known that every surface is capable of reflecting a certain percentage of the light which is focussed upon it, the nature and quality of the surface governing the quantity "thrown back." Therefore, depending upon what part of the face the light spot is moving over, so a variation of light or shade, or a combination of both, will be reflected back. Thus, on the forehead, for example, a reasonable amount of light would be thrown back, whereas when the spot traversed black or dark hair very little light would be reflected.

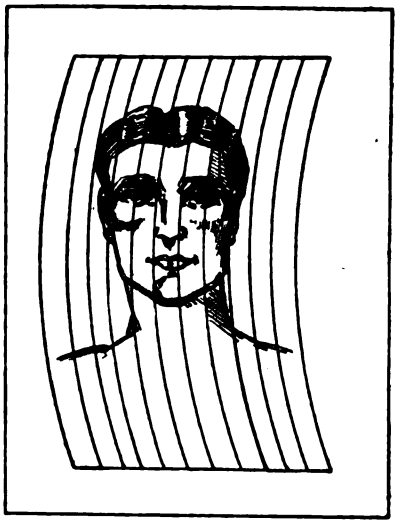


Fig. 2.—How a television image is built up of closely fitting strips.

Now this reflected light is "picked up" or influences the photo-electric cells which are arranged above the individual and between the screen and disc. These cells possess a very important property, namely, that they respond in an electrical sense to varying amounts of light and shade, and convert them faithfully into electrical variations of corresponding strength. That is to say, a strong light reaching the sensitive or active area of the cell will cause a relatively large current to flow in a circuit of which it forms a part, whereas weak light only produces a very weak and minute current.

Relative Terms

The terms used to describe the resulting current must only be looked upon in a relative sense, for in actual practice the currents are only fractions of a millionth of an ampere! Now, since these currents of varying intensity are proportional to the amounts of light and shade reflected from the face, they represent an electrical replica of the person's features. Owing to their minute nature they have to be amplified considerably, and then really correspond to the current effects produced by converting, say, a human voice through the medium of a microphone. The cells can therefore be looked upon as acting in the nature of a very efficient "light microphone."

It is these tiny currents that we can hear on headphones, as was mentioned earlier in the article, and although this turning of light into electricity is not new, it is little known, and later on, when we particularise, we shall have to deal with the discoveries which made this transformation possible.

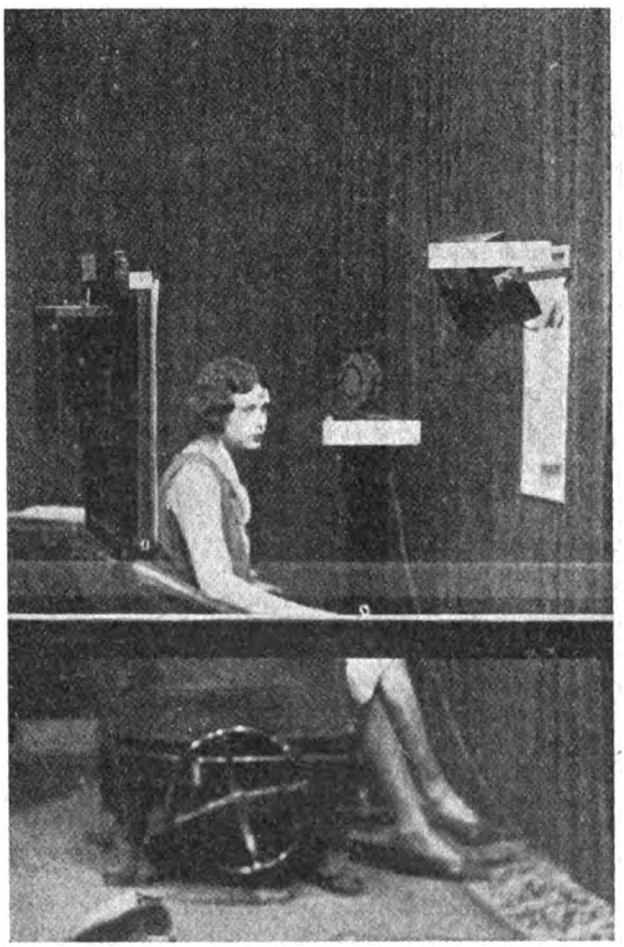
An Interesting Photograph

Actually, no personal discomfort is experienced by the person being televised, for the process of scanning the face with the spot of light is extremely rapid, and it only passes over the eyes for a very small fraction of a second. It certainly is a great deal more unpleasant to be in the beam of a theatrical floodlight than to sit in front of a television transmitter.

An examination of the accompanying photograph gives an impression of the scheme adopted. A lady is shown seated in front of a back screen, while the position of the photo-electric cells is plainly visible. The actual lamp and rotating disc is located behind the aperture in the draped wall, but illustrations will be published later showing how this is arranged. Note the microphone used for picking up the speech, song or music for the dual aural and picture broadcasting.

Tuning-in the Signal

Now the wireless process of broadcasting these currents produced by the photo-electric cells need not be dealt with here, for it is identical to that employed



View of a person being televised. Photo-electric Cells are above the opening at right. The Microphone can also be seen.

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for speech broadcasting, so let us transport ourselves to the receiving end, and imagine we have tuned in our set to the station that is broadcasting the television signals. We are rewarded with the distinctive but droning note which we mentioned earlier, and our next problem is to see how we can convert this sound or its electrical equivalent into something visible to the eye instead of being heard by the ear.

Have you ever tried the experiment of disconnecting the loud speaker from your set when you have tuned in a strong wireless signal and substituted one of those little neon lamps in its place? You will know the type I mean if you call to mind the familiar beehive pattern which are so popular as nursery night-lights. What happens? Why, signals become visible instead of audible, for you can see the flickerings of the lamp instead of hearing the vibrations of a diaphragm. But if you had tuned in a television transmission, then the flickering or light variations of the lamp must correspond to the amount of light reflected from the televised object, since this originally governed the signal intensity.

At the Receiving End

How can we spread these light flashes over a surface or area corresponding to that occupied by the original subject sitting in front of the transmitter? We know that an artist is capable of forming a picture from brush touches on a canvas, so we should be able to build up a picture from these light and dark illuminations of the lamp. Surely the easiest way is to more or less duplicate some of the transmitting apparatus.

Our first requirement, therefore, is a disc with the same number of holes positioned in spiral formation near the edge, and a motor to spin it round at the same speed and exactly in step with the transmitting disc. By being in step I mean to convey the impression that the relative angular position of, say, No. 1 hole on the shaft of the transmitter motor must be identical to that of No. 1 hole at the receiving end. This is what we understand by the term synchronism which is talked about so largely in connection with television, and about which I shall have something to say later on in this series, for it is of extreme importance.

Remember, also, that it is only in the Baird process of television that a commercially practicable scheme of synchronising is in operation. For this reason alone Baird is far ahead of any of his competitors, and this must be a source of pride to every Briton.

I know some of the readers of this new series of articles are beginning to ask questions of themselves as to why this process of transmission has to be gone through, and why certain pieces of apparatus, say, for example, the disc, have been chosen. I must ask them to bear with me, however, while the process is described in more or less general terms, for we shall then be in a better position to examine the scheme in detail and put forward reasons for choosing such apparatus. The broad outlines of what happens at the receiving end will be dealt with next month.

The "Wave Band" Theory of Wireless Transmission

(*Concluded from page 601.*)

must be put upon the fine-grained-ness of the image. That means the photo-electric current which controls the modulation at the transmitting end must be allowed to fluctuate as much as necessary and produce any required modulation of the carrier wave, provided the amplitude does not become so large as to disturb adjacent receivers tuned to a different wavelength.

There can be no disturbance produced by mere modulation provided the wavelength remains constant and the amplitude is not too great. This is proved by the fact that when a receiver is set to pick up 2LO broadcast it is in adjustment no matter what the pitch of the musical notes transmitted may be, whilst a receiver not accurately adjusted to 2LO is not disturbed. Accordingly, the 9-kilocycle rule is absurd as regards television because it merely limits the fineness of texture of the image without really securing freedom to other receivers from disturbance by the transmission.

It is just as absurd as it would be to limit the number of persons who may ride in a motor car, without limiting in any way its speed, with the object of securing safety to pedestrians in the same road.

Since the television image (at present) is built up of 30 scanning lines and is scanned in 1/12·5 second, the 9-kilocycle rule restricts each line of the image to about 24 changes of amplitude of carrier wave, and this is too little.

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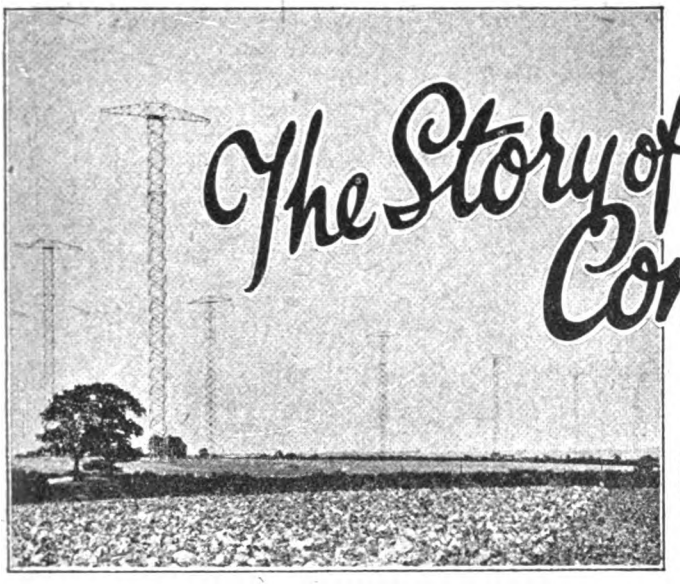

The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

PART XIV.

POINT-TO-POINT WIRELESS (II)

IN the last article we traced in broad outline the development of point-to-point wireless telegraphy from the first transatlantic circuit in 1902 up to the end of the war. As soon as the war was over, the Government again turned its attention to the development of the wireless communications of the Empire, and at the close of 1919 the whole subject was referred to a Government committee under the chairmanship of the late Lord Milner.

This committee produced a new scheme for imperial high power stations of the latest design, some with valve and some with arc transmitters, but the idea of a chain remained, an idea which was not welcomed by the Dominions or India, who wished for direct communication with this country and with each other, as opposed to communication through intermediate stations.

Marconi and the Post Office

With the knowledge then available, fortunately as it turned out, this direct communication was impracticable, and the scheme was being delayed, when in the spring of 1924 Marconi announced the extraordinary results which he had obtained by the transmission of short waves over long distances in the form of a beam. Within a few months the Post Office had signed a contract with the Marconi Company for the erection of short wave beam stations in this country for communication with similar stations in Canada, Australia, South Africa and India. At the same time it was decided that the Post Office should complete the erection of the English station at Rugby, under the old scheme. This station was to be by far the most powerful valve station in the world, and presented a host of problems which had never before been tackled.

It was an inspiring time for the wireless engineers of this country. They were erecting two new systems for world-wide telegraphic communication, one on short waves for communication with definite points, the other on long waves for broadcasting all over the world; and they were engaged on a third new system, in co-operation with the United States, for opening up transatlantic telephony for the first time in history. Ever since the war it had been said on all sides that England was being left behind in the development of wireless signalling. This great effort was to be the answer, and the rest of the wireless world, just a little nervous, sat back in its chair and waited.

England Takes the Lead

It had not long to wait. In January, 1926, Rugby started broadcasting messages by wireless telegraphy to stations and ships all over the world. In January, 1927, the Rugby wireless telephone transmitter got busy, and for the first time a commercial long distance wireless telephone service was established, viz., the transatlantic service with the U.S.A. In November, 1926, a commercial high speed wireless telegraph service on the Beam system was established with Canada, to be followed, in 1927, by similar services with Australia, South Africa and India.

Those two years, 1926 and 1927, changed the whole course of wireless development. England, far from being behind, had thrown into the melting pot all the long established ideas about world-wide electrical communication. The rest of the world had looked on and waited to see what would happen, and what

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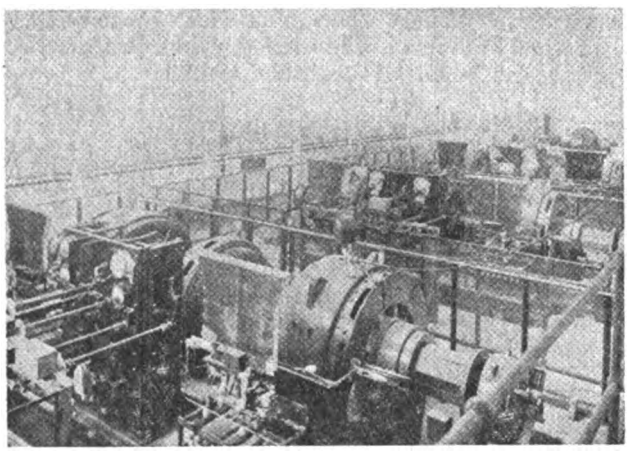
did happen was well worth waiting for; a new era had opened, and, honour to whom honour is due, this new era was the direct result of years of strenuous work on the part of our Post Office engineers, the engineers of the British Marconi Company, the engineers of the American Telephone and Telegraph Company and of the Western Electric Company, and last, but not least, the genius and driving force of the greatest of all wireless pioneers, the Marchese Marconi.

The Imperial Beam Services

Short waves had of course been used experimentally for several years before Marconi carried out his Beam experiments, but they had not been developed for commercial working. We have already seen how prominent a place was taken in the pioneering work on short waves by amateurs in this country and in the United States. The climax of these experiments was reached in October, 1924, when Mr. Goyder, then a boy at Mill Hill School, established communication with Mr. Bell in New Zealand, but much of this early amateur work has been rather overshadowed by Marconi's famous experiments which led up to the brilliant success of his Beam system as a commercial proposition.

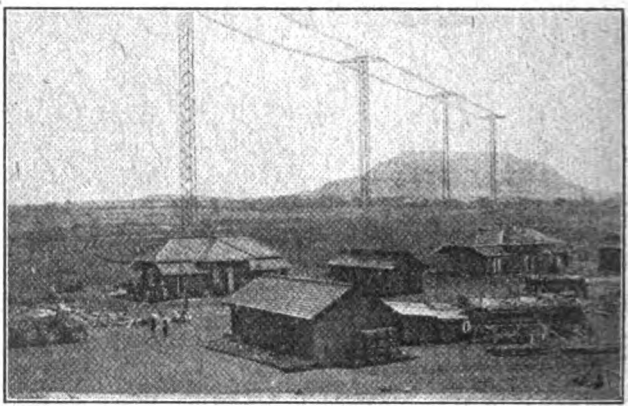
This success may be judged by the fact that the amount of traffic being handled by the Post Office on this system with Canada, Australia, South Africa and India was about 900,000 words a week when the circuits were transferred to the Merger Company in September last. The speeds obtained on these circuits vary from about 100 to 200 words a minute, duplex, according to conditions, but in regularity of working they are not yet up to the level of cables. The circuits, which were operated from the General Post Office, are now, under the merger arrangement, operated from Radio House in Wilson Street, London, and will be transferred later on to the headquarters of the new



The Power Room at Rugby.

company on the Embankment. The transmitting stations for Canada and South Africa are at Bodmin, and for Australia and India at Tetney, the receiving stations being at Bridgwater and Skegness respectively.

The wavelengths now used for each service are below 40 metres and are the result of practical trial. There is still much to be learned about the conditions of propagation of short waves, as these alter according to whether the great circle path which passes through the two stations is in daylight or darkness, or a combination of the two. Generally speaking, short waves



The Indian Beam Transmitting Station at Poona.

fall off in strength up to a range of about 100 miles, but waves below about 60 metres become stronger as the distance increases, and in daylight the shorter the wave the greater the recovery in strength. This is generally explained by the fact that, up to about 100 miles, propagation depends mostly on direct rays which are emitted from the aerial at low angles and whose energy is rapidly absorbed. At greater distances it is assumed that the increased energy is obtained from radiation which leaves the aerial at higher angles, travels along a conducting layer some 50 miles above the earth with little absorption, and is later on bent down to the earth again.

The power used at each transmitter is about 25 kw., and the methods of transmission and reception of signals are those described in a previous article which dealt with the latest developments of machine telegraphy; in fact, the operation of all modern point-to-point wireless circuits is now on the same lines as modern line telegraph working where the Morse code is used.

Advantages of Short Waves

The great advantage of being able to use short waves for long range communication is that far less power is required, which means not only a great saving in running costs but a great saving in capital expenditure. For instance, a world-wide long wave station like Rugby costs somewhere about £500,000 to erect, about ten times as much as a short wave station, and as the power used is in even greater proportion, the running expenses are much greater. Then, again, the speed of signalling of a short wave station is greater than it is possible to obtain from a long wave station, another advantage of the first importance, though, as a slight set-off to this, the regularity of communication is greater with the long wave station unless strong atmospheric disturbances are present.

(*To be continued*)

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The Economic Side of Television*

By *Dr. Ing. P. Goerz*

IN the present stage of the development of television to seek to judge its economic side would be tantamount to prophesying, and prophesying regarding the development of a sphere which is even now in its very early days, and has hardly left behind the laboratory era, is an unthankful task. Therefore to discuss the economic side of television within this compass one must confine oneself to making suggestions for an economic building up of the domain of television. If these suggestions are to be fruitful care must first of all be taken to see that they contain the germ of economy.

In the interest of a sound development it is to be hoped that the domain of television will not experience the same shattering which the development of wireless apparatus has undergone. We all know what an enormously rapid rise wireless had in Germany after its introduction, in which connection allowance must of course be made for the fact that it received assistance from the currency inflation existing at the time, which, as is known, inflamed the lust of enterprise of many manufacturers. Very shortly after the appearance of the stable currency many manufacturers disappeared from the picture, and in the course of years the construction and sale of wireless apparatus became more and more restricted to economically strong firms, and thus did wireless become an important economic factor in the German market.

It is not to be assumed that television will follow the same path, as the sphere itself is a much more difficult one than that of wireless, and even for this reason only those firms will concern themselves with the sphere which have suitable scientific collaborators at their disposal and also the requisite economic reserve for the thorough development of such apparatus. Furthermore, television is already so circumscribed by protective rights, or this territory will very shortly be so far surrounded with protective rights, that many firms will again be thereby prevented from constructing such apparatus.

Dr. Ing. Paul Goerz, the author of this article, is Technical Director of Zeiss Ikon, and Director of Fernseh A.G., the Baird Company's associate German Company.

As regards the individual systems of television, we are always confronted in this connection (in Germany) with the three well-known names of Karolus, Baird and Mihaly, and in the best economic interests of the new sphere one might even now wish that, just at the commencement of the various developments, the systems should unite and the groups themselves economically combine. Such a combination—loose or close—can hardly be long in coming, as the Reichspostzentralamt (German G.P.O.) must ultimately decide on

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a particular system of transmission, and so soon as this happens it may easily come about that one or other system will be thereby hindered in its further development.

This should not, however, be the object of the Reichspostzentralamt; on the contrary it may be assumed that this is precisely the office whose duty it is to inspire the closest possible combination of the three groups. It is also desirable that the Reichspostzentralamt should keep well informed regarding innovations in the transmitting sphere those firms which concern themselves with the manufacture of television receivers, so that they may take such information into consideration when building their apparatus.

Moreover, the recently formed Television Society should set itself the task of constantly working for the uniting of the systems and the economic collaboration of the inventors.

Precipitate Development—Warning

Whoever has had the opportunity of reading the articles which have appeared recently in many newspapers regarding television would have obtained the impression from these that the appearance of television receivers on the German market was to be expected before the end of 1929. As enough warning against a precipitate development cannot be given, it should first be stated that the reports were not in accordance with the truth. The Fernseh A.G. will, of course, deliver at the beginning of this year a batch of television receivers which, however precise, in view of a rational development will be small. It is to be readily appreciated that the initial batch will have to undergo further laboratory improvement. As, moreover, the judgment of the public has to be awaited, it would be uneconomic at this juncture to place large quantities of television receivers under manufacture. Further, every expert knows that the details of mass production work require much time to work out. Only after mature reflection from all economic points of view will it be decided to start mass production on a large scale.

There is also a further factor which remains to be settled, namely, the final fixing of the number of picture points. All television firms will probably agree that on the basis of the picture point number first laid down by the Reichspostzentralamt a television picture satisfying all requirements is not to be obtained. We do not disregard the fact that the difficulties which arise in the fixing of a higher picture point number are great, because for the transmission of these picture points higher frequencies are necessary than are to-day at the disposal of the wireless transmitters, if a disturbance of neighbouring transmitters is to be avoided.

It therefore remains to be seen whether a change to short waves comes any nearer to the solution of the problem, and how far the desirable coupling between picture and sound can be effected. The ideal is undoubtedly the installation of two transmitters with as similar a wavelength as possible, one transmitter being intended for the transmission of the picture and the other for the acoustic accompaniment. In any case the installation of two transmitters of very different wavelengths would hardly come nearer to the wishes of the public in that the ranges of the individual wavelengths are different, and the disadvantage can result that, for instance, in the distant foreign country televised pictures can be received on short waves, whilst the acoustic accompaniment by a transmission on long waves is no longer to be heard, and *vice versa*. For this reason also it would be advisable to wait upon development and not tie up unnecessary capital in the extensive manufacture of products which might later be unsaleable.

Because of the small quantities at first produced, the price of the apparatus will then be scarcely less than RM. 350 (£17 10s.). However, it may be safely assumed even at this juncture that these prices are susceptible of quite considerable reduction when manufacture on a large scale is begun. The sale of the apparatus should hardly be influenced by this price level, for, on the introduction of wireless, although the apparatus had long been introduced abroad, prices on this level were readily accepted and paid. Therefore the evolution of the prices will probably proceed along the same lines as in the case of wireless apparatus. It is probably to be assumed with certainty that even in a few years' time a cheap popular receiver will dominate the market as the cheap wireless sets do to-day.

Television will, however, apart from the transmission through the wireless transmitters, be able perhaps to conquer other economic spheres. For instance, the possibility is contemplated of supervising a warehouse from a central point from which the manager is in a position to observe what is going on in the separate departments. Just as to-day close touch can be maintained with various departments by microphones and loud-speakers, so will the simultaneous supervision of various departments be made possible by means of the televisor. A saving in supervisory staff would be thereby quite conceivable.

Police Uses

Further, one could imagine that the police might use television installations for various purposes, as, for example, the supervision of railway barriers, for the confrontation of criminals, or comparison of photographs with the original sent through the television transmitter. In this way time and costly journeys could be saved.

Again, the use of noctovision is contemplated—that is to say, the recognition of invisible light signals in darkness or fog; for instance, light signals at sea.

Finally, let us mention the use of television transmitters and receivers in business life, as, for instance, a combined television and telephone installation between two towns, or between two individual firms, which perhaps have their central establishment in the capital and their branches in the country, whereby

(*Continued on page* 617.)

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The Television Society

Fourth Meeting of the Session held on Tuesday, January 7th, 1930, at 8 p.m.

LECTURE ON

"Photographic Problems of Picture Telegraphy"

By *W. S. Newton*, B.Sc. (Hons.)

ABSTRACT OF LECTURE.

The paper discusses the problems encountered in the attempt to reproduce a transmitted photograph identical with the original.

A brief discussion of the Picture Transmission systems in use at the present time, comparing Bell, Siemens and Belin systems.

The effect of transmission on resolution.

The determination and the use of standard photographic methods in Picture Telegraphy.

THE novelty of receiving photographs by transmission over wires and radio has now disappeared and there is a demand that these pictures should have good definition and a pleasing gradation of tones.

This paper is an attempt to show how the photographic problems have been analysed and overcome in the Bell system of picture transmission now in use by the *Daily Express* between London, Manchester, and Glasgow. It is necessary to briefly describe the methods now used in picture telegraphy and the Bell system is taken as an example, but at the same time the paper comments on the methods of the Siemens-Karolus and the Belin system.

The photograph to be transmitted is prepared in the form of a photographic transparency 7 in. by 5 in. in size; the method of preparation being discussed later.

This is mounted on a cylindrical holder with the 7 in. as length and the holder is then placed on a carriage which is attached to a screw mechanism, the mechanism rotating so that the holder advances along its axis with each rotation.

The image of a small, brightly illuminated, rectangular aperture is focused on the film, the light transmitted being proportional to the density of the film.

This light illuminates the window of an anode ring potassium hydride photo-electric cell and the changes in intensity of illumination cause a corresponding change in electron flow.

The electron flow passes through a large impedance and the voltage drop is impressed on the grid of a three-valve battery coupled amplifier, the grid of the last valve being impressed by 1,300 c.p.s. frequency from a valve oscillator so that the output of the oscillator is modulated by the current pulses from the photo-electric cell.

The light spot has the same width as the thread on the lead screw, i.e., 0·01 in., thus the whole picture is scanned in the form of fine strips and the various densities in the film are expressed as modulations of the 1,300 cycle carrier.

The carrier current is amplified and transmitted over a telephone line which is suitable for the range of frequencies, produced by the modulation.

In the Siemens apparatus the original print is placed in the cylindrical holder 27 cm. in circumference by 18 cm. in length and the light spot is reflected back into the photo cell. Here the light,

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before incidence on the print, is interrupted by a rotating disc with holes in the periphery so that a carrier current of about 1,300 c.p.s. is produced and the output is amplified by a four-valve resistance coupled amplifier and transformed to the telephone line.

In the Belin apparatus reflected light is again used but a large portion of the print is illuminated and a small point focused into the photo cell, the carrier frequency again being derived by an interruption disc. Here prints 6 in. by 4 in. are used.

Receiving

Returning to the Bell system, at the receiving end the picture currents are amplified after passing through a high pass filter and then passed into a device called a light valve. This consists of a metallic ribbon strung in a strong magnetic field from a large field coil. The light valve is mounted on an optical bench so that the light from a lamp is focused on to the ribbon through an aperture in the field coil. By means of two movable jaws placed parallel to the ribbon, the ribbon when stationary can completely cut off the light.

When the picture currents pass through, however, the ribbon vibrates under the alternate polarities and when correctly adjusted the amplitude of its vibration is proportional to the modulation produced in the photo cell current. The light thus allowed to pass then falls upon a lens and is condensed on to a small rectangular aperture similar to that of the traversing light spot at the transmitting end. This aperture is focused on to the unexposed receiving film 7 in. by 5 in. mounted in a similar manner to, and rotating and advancing synchronously with, the transmitting film.

Thus as the lights and shades in the transmitting film cause greater or less modulation of the carrier, the ribbon allows more or less light to pass, and greater or less exposure is recorded on the film.

In the Siemens system the picture current coming from the line through a high pass filter is amplified and transformed to give about 600 volts which is placed across a Kerr cell.

Light from a lamp is sent through an aperture, lens and Nicols prism, Kerr cell Nicols prism, and is then focused on to the film.

The Nicols prisms are crossed so that, with a definite voltage on the cell, no light is passing, but the varying voltage across the Kerr cell changes the angle of polarisation of the nitrobenzene in the cell thus allowing more or less exposure on the receiving film which is mounted and moving in synchronism with the transmitting print.

In the Belin apparatus the varying amplitudes of the current change the angle of swing of an oscillograph which reflects a beam of light into an aperture, the light then being focused on to the film or paper.

Synchronisation

It is necessary for the transmitting and receiving films to be in synchronism so that the varying exposures at the receiver occupy the same relative position as the corresponding lights and shades in the transmitting film.

In the Bell system the transmitting machine is driven by a phonic impulse motor, which in turn is driven from a 110 volts D.C. supply at 60 cycles, the supply being interrupted by a 60-cycle tuning fork. The motor has a 10-point rotor and hence is driving at 360 revolutions per minute. The screw mechanism is geared 1 : 4 to the motor and the cylinder at 1 : 1 to the lead screw. Thus the cylinder rotates at 90 revolutions per minute.

The tuning fork also interrupts the output of a 490 c.p.s. oscillator, which is put to line through a low pass filter at 30 TU below the picture current level.

The 490-cycle current is rectified and operates a relay which supplies 110-volt D.C. to a similar fork at the receiving end. This fork drives the receiving motor and hence the two motors are always in synchronism.

It is also necessary to ensure that the two machines start in phase.

Both lead screws are operated to the motors by means of a mechanical clutch magnetically operated and when at rest the clips holding the ends of the films are stationed in front of the light spots.

The transmitting clip is pierced by a small hole which allows light to pass into the photo cell and send current to the line. This current is then rectified at the receiving end by operating a self-locking relay which changes the amplifier to a rectifier and causes another relay to break the clutch circuit when the driving key may be thrown over. Upon receipt of the start signal from the receiving station the transmitting operator starts his clutch current, the

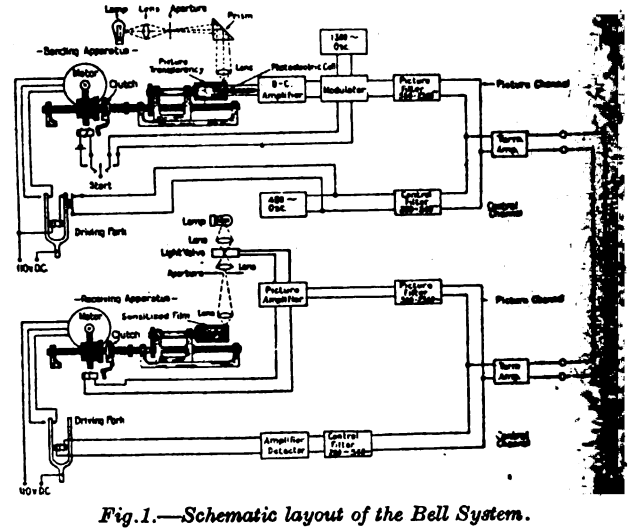

Fig.1.—Schematic layout of the Bell System.

switch at the same time interrupting the picture carrier. This interruption releases the clutch relay and the receiving machine starts in phase with the transmitter, and the amplifier is then back into the picture condition, i.e., passing alternating current into the light valve ribbon.

In the Siemens system the machine is driven by a D.C. motor governed by an A.C. motor working from

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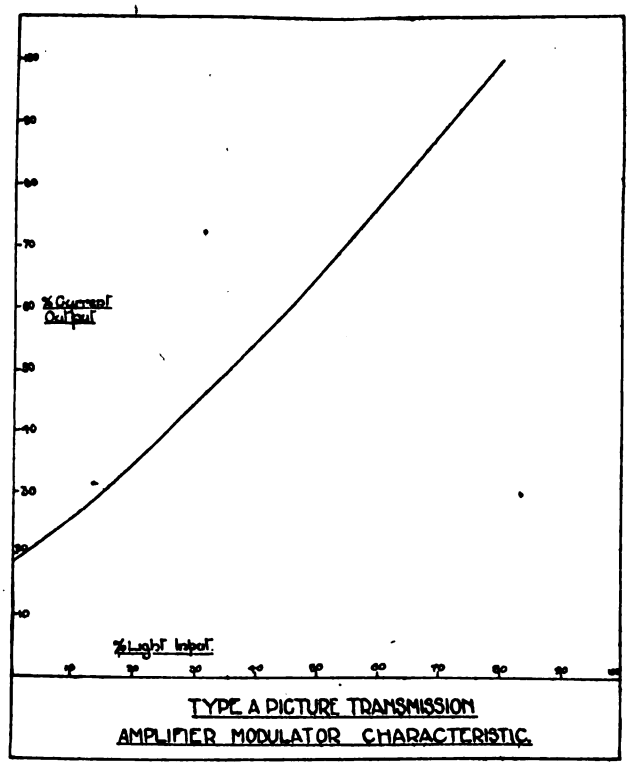

Fig. 2.

the amplified tone from a 1,600 c.p.s. valve-driven tuning fork. This fork is thermostatically controlled and has constant speed.

At the receiving end a similar fork governs the receiving machine and as the forks are entirely independent, fork frequency is amplified to line and compared stroboscopically with the receiving fork, the frequency being slightly adjusted by reaction on the receiving valve condenser.

For phasing, the two film drums can only fit the rotating shaft in one position and at the transmitter a small white spot on the drum sends tone to line at each revolution. By observing the rotation of the receiving drum against a neon lamp illuminated by this current the two machines can be brought into phase by rotating the stator of the driving motor.

No starting relay is thus necessary since both clips pass the light spots at the same time.

In the Belin apparatus phonic wheel motors driven by a 30-cycle fork are used and relay starting causes both machines to start in phase.

The general schematic layout of the Bell system is given in Fig. 1. This brief description serves to establish the relationship of the transmission characteristics subsequently mentioned.

Resolution

The first essential of a photograph is that it should be sharply defined and hence transmitted pictures must have as good resolution as possible.

With a given transmitting medium such as a telephone circuit and a given size of picture, the speed of transmission is inversely proportional to the resolution.

In the Bell system the actual photograph is $6\frac{1}{2}$ in. by $4\frac{1}{4}$ in. on a 7 in. by 5 in. transparency, the loss being required for mounting, the circumference of the holder being 5·5 in.

The pitch of the lead screw is 0·01 in. and hence the structure of the picture received is of that dimension. Since the exposure on an aperture image represents the average tone value of that portion of the picture, distortion is inevitable. It is found that with a structure less than 75 lines to the inch this distortion is resolved by the eye. Since time of transmission is an economic factor, and that to obtain structures over 100 lines to the inch gearing must be used, 0·01 in. is taken as the structure width. The scanning spot is 0·01 in. by 0·0075 in., and at 90 revolutions per minute the linear speed of the film is 8·25 in. per second.

Thus the highest modulating frequency is from clear film to opaque film and back to clear film, and this must take place in two aperture heights.*

Thus the maximum modulating frequency is

$$\frac{8{\cdot}25}{0{\cdot}015} = 550 \text{ c.p.s.}$$

Since a frequency p modulated by frequency n gives frequencies p, $p+n$, $p-n$, the band of frequencies

* The relationship of aperture length to cyclical variations is discussed in Horton's "Transmission of Pictures and Images," Proceedings of the Institute of Radio Engineers, Vol. 17, No. 9.

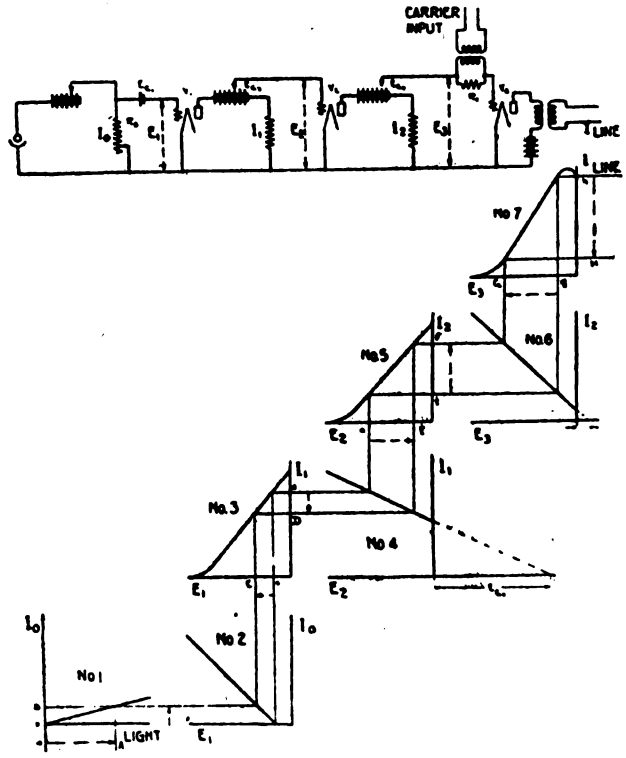

Fig. 3.

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required at 1,300 cycles carrier current is 750 c.p.s. to 1,850 c.p.s., for which range a telephone line will give a flat attenuation frequency characteristic.

If aerial wires are used with a cut-off of 6,000 c.p.s. a carrier frequency of 4,000–5,000 cycles would be used and hence the speed increased three times.

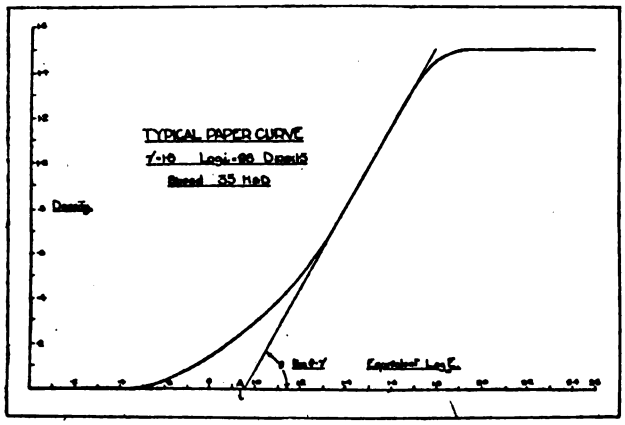

Fig. 4.

Thus all picture systems now in use over telephone lines have a scanning beam of about 100 lines to the inch and take approximately one minute to transmit 1 inch.

Another factor is that of transients. If portions of the apparatus or the circuit are overloaded or over-equalised, or if the wrong aperture height is used, a transient effect is produced which owing to the sensitive nature of the photographic recording, completely mars the sharp delineation between black and white. Again irregular impedances on the line will cause echo, which results in ghosts, or white shadows, on the picture.

The optical arrangement at both transmitting and receiving ends is a big factor. The scanning beam is often diffused by the fact that long optical systems containing prisms are used, and scattering is inevitable in the reflected light method.

At the receiving end the image on the film should be the sharply focused image of the aperture, which should be adjustable so that the structure does not overlap or underlap but forms a flat surface.

Photographic Problems

The aim in picture transmission is to produce a transmitted photograph, which has the exact tone gradation of the original picture.

Everything is governed by the transmitting characteristics of the apparatus and it is essential that the relationship between the photo-cell circuit and the transmitting and receiving apparatus be carefully studied and analysed.

The amplifier-modulator characteristic is obtained by plotting % light input to the photo cell against % current from the amplifier-modulator.

This is shown in Fig. 2.

It is desirable to have this curve as straight as possible with a slope of unity, and the curve shown meets these requirements except for a slight bend at the bottom end.

The controlling factors are the voltage on the cell, this voltage being well below that for ionising point, and the adjustment of the bias voltages in the amplifier.

The arrangement of these is shown in Fig. 3.

The density limits of the transmitting film are determined by the ratio of exposure through this film to current output, and it is necessary here to give an explanation of the definitions and photographic principles used.

The following definitions are required :—

(1) Transmission $= \dfrac{\text{Transmitted or Reflected Light}}{\text{Incident Light}}$

(2) Opacity $= \dfrac{1}{\text{Transmission}}$

(3) Density $= \text{Log}_{10}$ Opacity

(4) Log E $= \text{Log}_{10}$ of the per cent. light reflected or transmitted in making the exposure.

The exposures are given in relative values, and to avoid negative logarithms the % opacities are taken as whole numbers.

Light from unexposed and fixed out paper is taken as 100 per cent. reflection and for film 100 per cent. transmission is full illumination on to the measuring device with nothing interposed.

If the densities resulting, after development from a given series of exposures on a photographic emulsion, be plotted against the log E of these exposures a curve similar to Fig. 4 is obtained.

The slope γ of the curve represents the contrast, or the tone gradation in the photograph and this

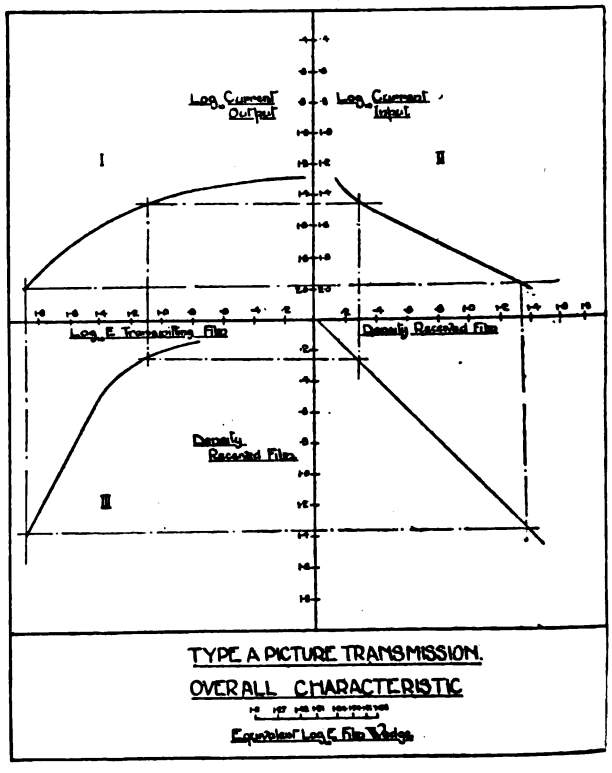

Fig. 5.

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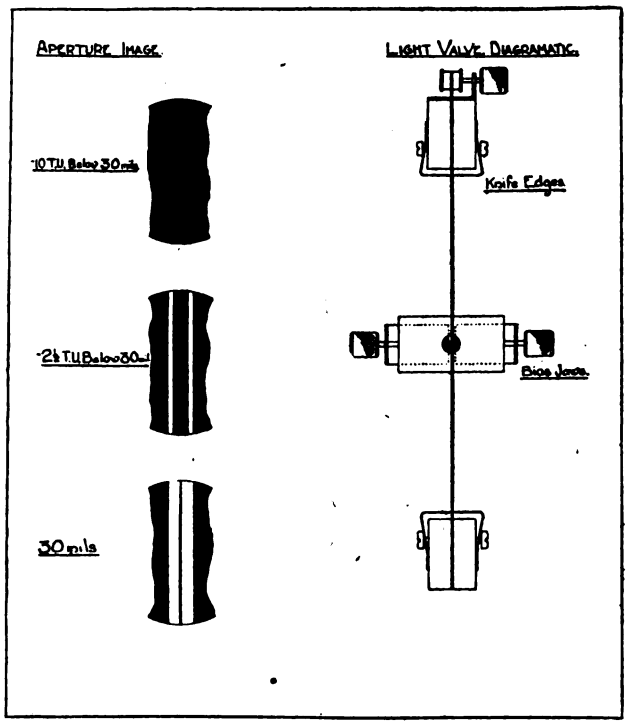

Fig. 6.

contrast swings round the point A according to the time and temperature of development.

It will be noticed that the curve flattens out in the blacks and whites and to avoid loss of detail in these portions it is necessary to fix the exposures so that the curve is used between the toe and shoulder.

The point A where the straight line cuts the axis is given by the speed of the emulsion, the speed being $=k/\log i$, where k is some constant for convenience so that speeds can be given in whole numbers, i.e., we speak of a plate as having an H. and D. speed of 80.

This photographic characteristic has to be combined with the transmission characteristics so that each photographic reversal will give as a graph a straight line with slope of unity to give correct tone reproduction. If one step deviates, another one must be adjusted to compensate for it.

In transmitting a picture a photographic reversal is made, i.e., if a negative transparency is used on the transmitter a positive is received and vice versa. This is necessary since the curvatures of the photographic emulsions would be accumulative, as will be seen if a reversal was not made (Fig. 10).

Consider the ordinary photographic process of making a print from a negative. According to the exposure given while taking the negative and the subsequent development a characteristic will be obtained, similar to the curve in Section I., Fig. 4 (A).

The density range in this negative will give the exposure range on to the paper, the characteristic of which is given in Section III., Fig. 4 (A).

Now if the object brightness of the print—i.e., log % reflection—be plotted against the object brightness of the original—i.e., $\log_{10}E$ on the negative—it is obvious that for the print to match the original in tone gradation this curve must be linear and have a slope of unity.

This curve is given in Section IV., and it will be seen that to obtain a good curve the products of the γs of the negative and print must equal unity and the exposure range on the negative must not extend over the straight portion of the curve.

The straight line in Section II. is used to transfer the densities of the negative on the ordinate to exposures on the abscessæ, and we can regard picture transmission as the making of a print from a negative at a distance where the straight line in Section II. represents the transmission characteristic. The difficulty is that whereas in making an ordinary print the paper may be chosen to suit each negative, in transmission the receiving operator has no knowledge of the transmitting negative and hence standard methods must be used.

In actual practice the transmission characteristic is not quite linear, and its slope is not unity, but the γs of the photographic curves are adjusted accordingly.

Thus the problem consists of obtaining Fig. 4 (A), Section IV., but this time including the transmission apparatus.

The next step is to obtain a curve plotting $\log_{10}E$ of transmitting transparency against log % current output from the amplifier-modulator (Fig. 5, Section I.).

Since the base of the film absorbs 20 per cent. of the light, maximum current is given by a $\log_{10}E=1{\cdot}9$.

It will be seen that the change in log E from 0 to 0·8

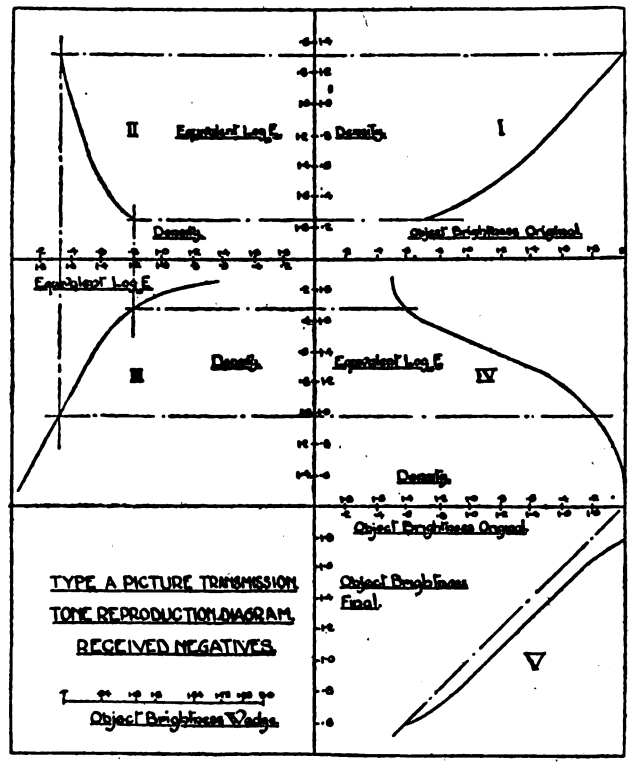

Fig. 7.

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makes very little difference to the current output and hence the transmitting transparency must have an exposure range from 0·8 to 1·8, i.e., density range from 1·20 to 0·2, since it is not advisable to have absolutely clear film in the high lights of the transparency.

It will be noticed that there is a current difference of 0·7 in log values, i.e., 14 TU, and before transmission the output from the amplifier-modulator is in the light condition passed into a resistance pad with 14 TU loss in order to adjust photo-cell voltage so that there is this current loss between clear and opaque film.

To plot the receiving characteristic a few details of the receiving apparatus are needed.

The illumination of the receiving lamp is fixed at a definite value and the current input from the line is amplified so that 30 mils is passing through the light ribbon valve, the tension of which is adjusted so that it has a natural frequency of 2,600 c.p.s. Thirty mils is the current for clear film at the sendint end and −14 TU below 30 mils gives the current (6 mils) for opaque film.

The exposures on the receiving film must now be arranged between these current values.

This is done by adjusting the bias jaws on the light valve so that definite predetermined densities are obtained for currents $-2\frac{1}{2}$ TU and −10 TU below 30 mils. This is the standard method of adjustment, Eastman process film, 5 minutes development in D 14 at 65° F. being used. Fig. 6 shows a diagrammatic sketch of the ribbon strung between the bias jaws and the illumination which passes through the aperture for different currents through the ribbon.

By measuring the densities for a series of current values between 30 mils and 14 TU below 30 mils and plotting these densities against log % current input the receiving characteristic is given (Fig. 5, Section II.).

The slope of this curve can be altered by taking various densities for $-2\frac{1}{2}$ TU and −10 TU, and this curve is the one used to correct deviations in other curves from the unity slope. If the contrast is decreased beyond a certain limit the curvature at the toe of the curve also increases and a choice must be made between these two factors, always bearing in mind that the lower point is fixed by the current output not falling below $\log_{10}$ % current=1·3.

Combining the transmitting and receiving characteristics gives the overall characteristic (Fig. 5, Section III.), and from this curve it is possible to

Fig. 8.—(LEFT) *Original.* (RIGHT) *The same picture as received by the system described.*

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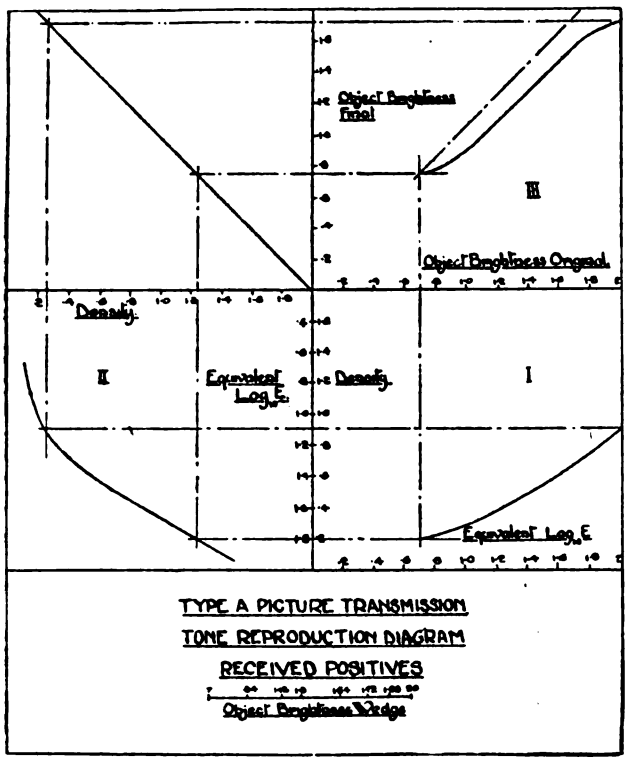

Fig. 9.

find the density on the received film for any exposure through the transmitting film.

Whether a negative or a positive is received depends upon the time and circumstances, the former process requiring two more photographic steps than the latter.

Receiving a Negative

The original photograph is copied to give a plate negative, from which the film positive is prepared.

In order to have standard methods, a special copy-camera bench is used and time-temperature development in Eastman D 14 developer.

The illumination on the bench consists of four large lamps spaced equidistant from the axis of the camera lens and placed such a distance from the screen that uniform illumination is given over a considerable area.

Since it is necessary to copy all sizes of prints to a 7 in. by 5 in. negative and hence have varying illumination on the image, an exposure facture is used to correct for this variation.

$F=v^2/4f^2$ Where F=exposure factor.
v=distance of image from lens.
f=focal length of lens.

From this equation a scale is made which gives the variation in time necessary to give the same exposure as in a 1 : 1 copy, for any position of the camera lens, i.e., if time of exposure is 10 seconds in 1 : 1 position and in 1 : 2 position the lens is at 0·8 on the scale, 8 seconds exposure is given.

To investigate the photographic curves a wedge of paper densities was made, the densities ranging from white to black. The reflection densities were measured and the relative exposures or object brightness from the wedge thus obtained.

The wedge was copied at 1 : 1 on Illingworth ordinary plate, H. and D. 80 exposure being 10 seconds at *f*—11, 3 minutes development in D 14 at 65° F.

Plotting the curve (Fig. 7, Section I.).

This gives a maximum density of 1·13 and has a γ of 0·58, while a fairly straight curve is given.

A film positive is prepared from the negative in a projection camera, the ratio being 1 : 1. An exposure of 15 seconds at *f*—22 is given on Eastman commercial film 7 in. by 5 in., and this is developed for 1½ minutes in D 14 at 65° F., giving a characteristic as in Fig. 7, Section II.

To obtain this curve the equivalent $\log_{10} E$ of the densities of the copy negative shown in Section I. are plotted against the measured densities of the film.

This gives a maximum density of 0·90 and a minimum density of 0·30 and has a good slope, and it will be noticed that the curve is so arranged that it extends over the straight portion of the overall characteristic.

From the above data tone reproduction diagrams* were plotted, i.e., the exposures from the film positive were transposed to densities on the received negative by means of the overall characteristic.

It is necessary to make a print from the negative and the paper used is normal press bromide. The

* This method of photographic analysis was devised by Dr. L. A. Jones, of the Eastman Kodak Laboratories, Rochester, N.Y., and published in his paper "On the Theory of Tone Reproduction with a Graphic Method for the Solution of Problems," in the *Journal of the Franklin Institute*, July, 1920.

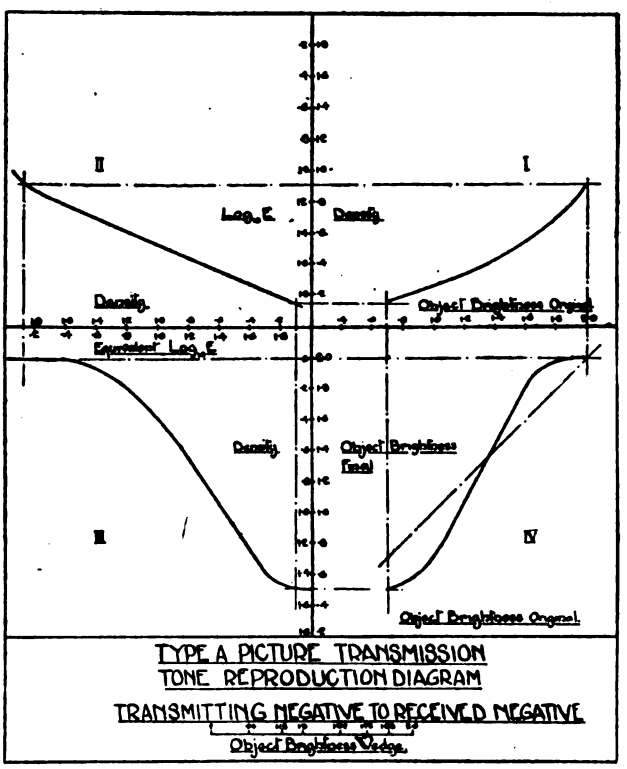

Fig. 10.

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An example of a photograph received from Berlin on January 7th, the opening day of the new London-Berlin picture telegraphy service. The system employed is the Siemens-Karolus.

relative exposures on this paper will, of course, be given by the range of densities of the received negative and the tone reproduction diagram (Fig. 7) consists of the interpolation of the transmitting positive II. to the overall characteristic III., and then to the paper characteristic IV., when a wedge of densities similar to the original is produced.

By comparing the reflection densities of this wedge with those of the original we should have a straight line with slope of unity and this is shown in Section V. of the tone reproduction diagram. The important thing is not to produce the exact densities as in the original but to produce the same tone gradation.

It is to be noticed that the half-tones are correctly reproduced but that there is a slight loss of detail in the ends of the blacks and whites. This loss will be noticed in the comparison of transmitted against original picture in Fig. 8.

Received Positive

In newspaper work time is valuable and a method was evolved whereby two steps in the above process were deleted: (1) the making of positive transparency; (2) the printing from the received negative.

Here the copied original gives a film negative and a film positive is received and sent direct to the art department.

The negative is made on Eastman commercial film, 10 seconds exposure at $f-22$, 4 minutes development in D 14 at 65° F.

This has a characteristic given in Fig. 9, Section I.

Maximum density 0·88, minimum density 0·17, and again extending over the straight portion of the overall characteristic. Using this in a tone reproduction diagram (Fig. 9) we have a very good curve for object brightness original, against object brightness, transmitted picture.

This method gives very good results since definition is improved by removal of two processes and the fact that standard methods can more easily be adhered to, whereas in making the print from the received negative the photographer has a tendency to use his own judgment.

It is also found that better process blocks can be made by transmitted light through the film than by reflected light from the print.

Fig. 10 shows the result of receiving a picture without a photographic reversal. The transmitting characteristic is now reversed by reversing the battery connections on the photo cell and the resulting tone curve is very contrasty and flattens off very much at both ends, in other words, the received picture is "soot and whitewash."

Experiments have been made to receive a print on paper instead of on film to allow for retouching

Another picture received from Berlin on January 7th. The charge provisionally fixed for the transmission of a photograph is £1 for a picture of 15 square inches.

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and almost perfect tone reproduction was obtained, but the latitude of the paper is so small that the adjustments of density for $-2\frac{1}{2}$ TU. -10 TU have to be so exact that the practicability of the method under working conditions is doubtful.

This method of analysis and construction could no doubt be applied to the Siemens apparatus, but up to date no opportunity has been available to make any experiments.

In conclusion, acknowledgments are due to Mr. F. G. Gardner, of the Western Electric Company, for permission to use the diagrams and data of the Bell system in this paper.

* * *

At the conclusion of the lecture Mr. E. S. Ritter, M.I.R.E., a member of the Post Office Engineering Staff, who was in the audience, announced that he had brought with him some examples of photographs received from Berlin that day by the newly-opened London–Berlin phototelegraphy service. These were handed round and much admired by the members. Some of them are reproduced here.

* * *

Society Notes

The next meeting of the session will be held on Tuesday, February 4th, at the Engineers' Club, Coventry Street, London, W.1, at 8 p.m., when Mr. G. P. Barnard, Grad.I.E.E., will give a lecture on "The Photo-Conductivity of Selenium and various other Substances."

Informal discussion (members only) at 7 p.m. on Mr. Newton's paper on "Photographic Problems of Picture Telegraphy."

* * *

The lecture tour, December 10th to 19th, 1929, undertaken for the purpose of helping members interested in the formation of local groups, was much appreciated.

Large audiences attended, mostly of technicians strengthened by members of the local radio and scientific societies.

For the organising arrangements the Society owes its best thanks to the Association of Engineering and Shipbuilding Draughtsmen.

Following the lecture and demonstration, discussion was allowed, and finally arrangements for the formation of a group centre of the Television Society was made.

The following gentlemen promised to act as local secretaries (*pro tem.*), and all interested in these districts should send in their names:

LIVERPOOL.—E. G. Lewin, Esq., M.Sc., A.Inst.P., Castle House, Harwarden, Chester.

MANCHESTER.—T. C. Dickie, Esq., Regent House, Cannon Street, Manchester.

ROCHDALE.—S. Thorn, Esq., 31, Queen Victoria Street, Rochdale.

LEEDS.—H. Wolfson, Esq., The Dingle, Grove Lane, Headingley.

SHEFFIELD.—H. Taylor, Esq., 29, Edale Road, Ecclesall.

DERBY.—A. Evans, Esq., 383, Brighton Road, Derby.

WIGAN.—M. M. Das, Esq., B.Sc., Physics Laboratory, Wigan and District Technical School.

The lecture given before the Birmingham Midland Institute by Dr. Tierney was followed by the formation of a group centre at Birmingham, and readers interested should communicate with the local secretary, F. L. Farmer, Esq., 472, Bordesley Green, Birmingham.

It is with regret that we announce the death of one of our active members, Mr. E. J. Baker, of South Side, St. Sampson's, Guernsey.

Mr. Baker constructed one of the early pattern television receivers, and his reception of television images was very successful.

The hon. treasurer directs attention of members to the recent notice reminding them that subscriptions for the current year are now due.

Members will facilitate the work of the Society by forwarding their remittances to the hon. treasurer, Television Society, 4, Duke Street, Adelphi, W.C.2.

Now is the time for new members to join, and the form of application issued in this journal will receive immediate attention when forwarded to headquarters.

J. DENTON,
W. G. W. MITCHELL,
Joint Hon. Secretaries.

The Economic Side of Television.

(*Concluded from page* 608.)

business people will be afforded the possibility of hearing and seeing in the picture the person with whom they are in communication. It often happens to-day that in important business conversations the one call is not enough; it is frequently necessary to check the accuracy of the report or the identity of the communicant by a counter-call.

Moreover the distant transmission of Sanscrit and other pictorial languages, the wireless telegraphic transmission of which is impossible, should not be forgotten in this connection.

It would lead too far to mention within this compass all the spheres which sooner or later would permit of the application of television. It is, however, to be hoped that the new sphere of activities will create for itself an *entrée* into as many economic circles as possible, and develop into a sound branch of industry in the interests of a strengthening of our German economic life.

EXPERIMENTAL WORK OF ALL KINDS Scanning Discs, Inventors' Models.—JOHN SALTER, Scientific Instrument Maker (Established 1896), Featherstone Buildings, High Holborn, W.C.1.

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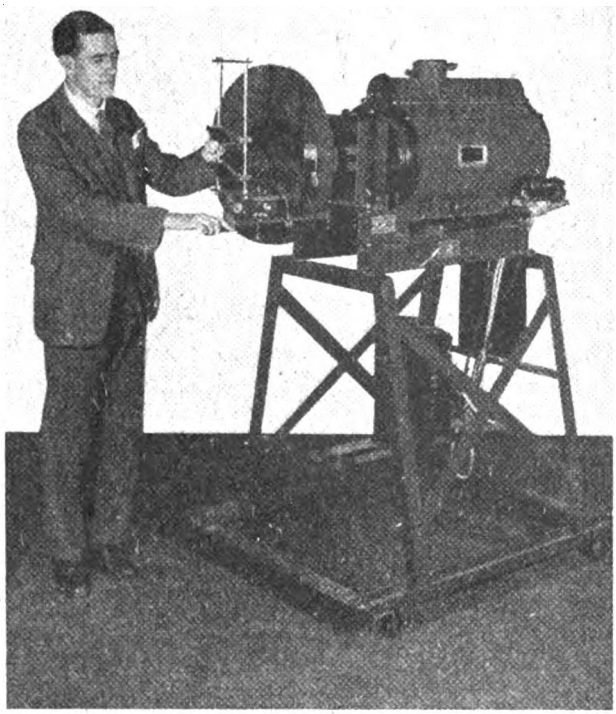
Baird Television *in* America



A television transmitter developed by the Baird Television Corporation of America, showing the "periscopic scanner," an arrangement of mirrors.

DURING recent weeks there has appeared in some English newspapers a short paragraph giving the opinion of Mayor James Walker, of New York, that the next Presidential election would see television in use everywhere and would be used to broadcast complete political platforms of speakers during the campaign. This paragraph and the opinion quoted is the very small echo that the daily papers here have gathered of a demonstration of television given by the Baird Television Corporation of America in New York, in December last.

Mayor Walker, Miss June Collyer, Miss Betty Compson, Miss Irene Delroy, Mr. Mayer Gordon (the B.B.C. solo violinist) and many other stage and screen stars, together with prominent Americans, were televised at a very successful demonstration. Mayor Walker, in addition to the remark already quoted, also said at the close of the demonstration that compared with the early cinema shows the demonstration of television he had just witnessed was miles ahead.

These statements were made good use of by the American newspaper men in their reports, but the thing that seemed to surprise them most was that a newspaper, held before the transmitter, could be seen in the "televisor," and the headlines read. Tele-reading also seemed to strike them as being rather remarkable. All of which, of course, is a tacit admission that the standard 30-hole disc as used by all the Baird Companies is capable of giving much better definition than the experts believe, and that Baird television is better on the whole than that so far shown in America.

The real interest in the demonstration, however, lay in the use of a new "periscopic" scanner, which enables any selected portion of the studio to be transmitted. This is the invention of the Baird Television Corporation of America, and enables the spotlight beam to be turned about in any direction like a searchlight. If artistes are seated or standing, tall or short, does not matter, the beam can be directed on them. In the past, artistes being transmitted had to keep in a sharply defined area. This meant the use of a special chair which could be raised or lowered according to the height of the person being transmitted. Further, nothing outside the direct line of the beam could be sent. Now artistes can place themselves comfortably, and the engineer in charge of the studio sees that they are scanned properly, by simply adjusting the beam to cover them. This is done by an arrangement of mirrors placed immediately in front of the focussing lens of the spotlight projector. The first mirror reflects the light upwards on to a second mirror which throws it forward. By adjusting the angles of these mirrors in relation to one another and in relation to the optical axis of the lantern, the scanning beam can be directed in any required direction. The accompanying photograph shows the device clearly.

Broadcasting Facilities Applied For

According to the American press reports received, Captain O. G. Hutchinson, the Joint Managing Director of the English Company, who is at present in America in charge of the demonstration, stated that the Baird Corporation are applying to the Federal Radio Commission for permission to conduct television experiments during the evening hours.

So far no attempt has been made in America to transmit speech and television together. This, the Baird Corporation seek to do, to prove that television has a definite entertainment value in conjunction with broadcasting.

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Low Frequency Amplifiers for Television

PART II

By *William J. Richardson*

LAST month we referred briefly to the six-circuit diagrams which were submitted as being suitable for television amplifier work, and pointed out a few of the essential features which have to be considered if good results are desired. Two articles have appeared in the October and January issues of this journal, under the title of " Television and Your Wireless Receiver," in which the main details of the receiver in general have been ably expounded, so we can confine our remarks concerning the amplifier to outstanding points.

Output Strength

Let us presume that the detector and high frequency section of the set (if this latter should be required) have been efficiently designed on the lines mentioned in the articles just quoted. Then the low frequency amplifier must be capable of dealing faithfully with the signals from the detector valve, and pass on an output to the neon lamp which is in no way distorted, otherwise, of course, the picture will be spoilt. As a judge of the signal strength required for securing a good picture, we can say that the television note as heard on the loud-speaker must be of good strength. That is, somewhat above the usual comfortable listening standard but nothing approaching the volume required for a public address system.

Many people are under the impression that the output signal must be of such a magnitude that it would fill a hall if handled by a loud-speaker or loud-speakers. This is quite erroneous, so the reader should dismiss it from his mind at once. Just bear in mind that in the televisor receiver the output power has to operate a neon lamp, and hence the necessity for a stronger output than one usually associates with a wireless set or low frequency amplifier.

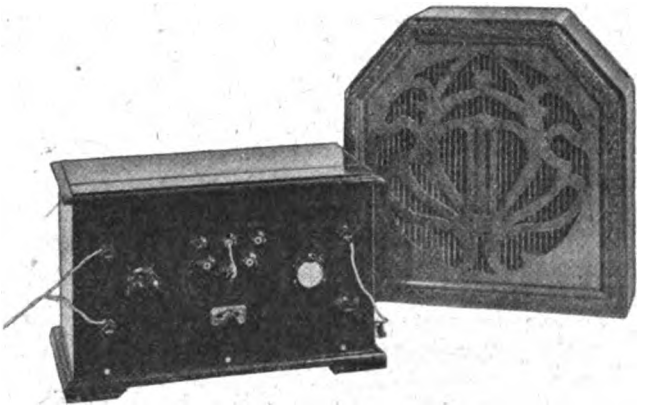
" Over-cooking "

Any attempt to secure too strong a signal will only result in an " over-cooked " picture. That is, too great a contrast will exist between light and shade, and the picture will be spoilt. This is comparable in wireless parlance to an over-loaded loud-speaker. Generally, it is advisable to arrange for the output from the amplifier to be switched over to a loud-speaker or the neon at will by means of a change-over switch, as in addition to judging signal strength it is often advantageous to tune in the television signal by ear. The characteristic rythmical hum is no doubt familiar to readers ere this.

In this connection do not forget to alter grid bias on the last valve when effecting a change-over. The neon will require a lower negative bias when working than is required for the loud-speaker, and the output valve plate can get red hot if the bias is not increased when using the speaker, and, naturally, this is detrimental to valve life.

Frequency Range

Now for another important side of the amplifier design which must be considered. This is the frequency range to be handled. Many and varied have been the discussions on this point alone, but, unfortunately, in many cases the theories propounded have been based on incorrect foundations. At present the side-band allocation for television broadcasts is the same as that for speech and music, namely, 9 kilocycles. It is to be hoped that in the near future this will be extended without any recourse to the use of the ultra short waves, but since good results are now being obtained within this frequency band, what of the theorists who with paper and pencil prove *conclusively* that television would invade the ether on a kilocycle front of hundreds of thousands ? They must have got muddled with their ciphers !



It is generally advantageous to be able to switch the amplifier over to neon or loud-speaker at will by means of a change-over switch, such as that shown at bottom, centre of this photograph.

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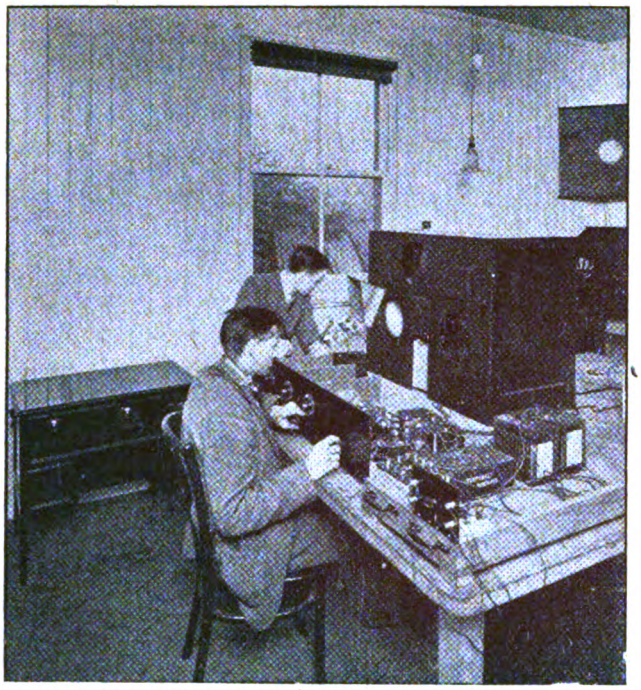

A special amplifier undergoing an actual "visual" test at one of the Baird Company's laboratories.

In considering a television picture we must remember that the higher frequencies are responsible mainly for the detail, and any undue loss of these frequencies gives the picture a rather woolly or somewhat hazy appearance. On the other hand, cutting off the lower frequencies will evidence itself in the picture as undesirable dark shadows, while the presence of pure white or any strong surfaces tends to throw these up somewhat.

Any mathematical calculation which proposes to specify the *exact* frequency limits required for television is extremely complicated, and must take account of disc dimensions, speed, number of holes, etc. Actually, the amplifier should be able to handle frequencies down to zero, but provided the limit of thirty or forty is reached efficiently then there will be little trouble. At the other end of the scale, the lower the cut-off of the higher frequencies the greater will be the rounding-off and smoothing over of any sharp contours, so that very small details are apt to be lost.

Again, the narrower the side-band allocation for television the more restricted becomes the scene which can be transmitted with intelligent recognition. However, with the present 9-kilocycle limit it behoves the constructor to make sure his amplifier will work up to this without any marked falling off in its characteristic.

For the Best Results

Practice has proved that the best results generally are achieved by resorting to relatively low amplification per valve stage and employing several stages. This is preferable to, say, attempting to secure all the amplification in one or perhaps two stages. Resistance capacity coupling is most favoured as a rule, but really first-class push-pull amplifiers are capable of giving excellent results.

Now let us refer to the first of the circuit diagrams given last month and reproduced here as Fig. 1. The inter-valve coupling condensers C_1, C_2, and C_4 should be of the high grade mica type with a capacity of 0·1 mfd. Naturally, the exact values of the plate resistances, R_2, R_4, and R_5, and the grid resistances R_1, R_3, and R_6 are dependent upon the valves employed, and it is suggested that V_1 be as an LS5B, V_2 an LS5, and V_3 and V_4 two LS5A's in parallel. Frequently one of these LS5A's can be dispensed with and good pictures obtained. Everything will depend upon signal strength, etc. R_4 and R_5 are shown as two resistances in parallel in the plate circuit of V_2, owing to the fairly high plate current that generally passes in this circuit, but if power resistances such as the Varley or Ferranti type are used, then one will be sufficient to handle the power. Remember that if one resistance replaces the two shown it should be one-half the resistance value of R_4 or R_5.

Picture Brightness

With the neon lamp itself in series with the output valves it becomes necessary to use at least a 350-volt high tension supply capable of delivering an output of 30 to 40 milliamperes. The actual consumption will depend largely upon the ambitions of the operator. In other words, if he requires a very bright picture, or "neon field" as it it is generally termed, then G.B.—3 must be reduced accordingly, and plate milliamps will rise. On the other hand, a judicious handling of the grid bias values will bring about quite an appreciable reduction in plate current without detracting from the picture in any way.

Full details concerning the use of the separate synchronising valve illustrated in Fig. 1, and test results with an amplifier made up in this fashion, will be given next month. I also hope to include a suggested layout with wiring diagram, so as to form a basis for experimenters to build up their own apparatus and make tests.

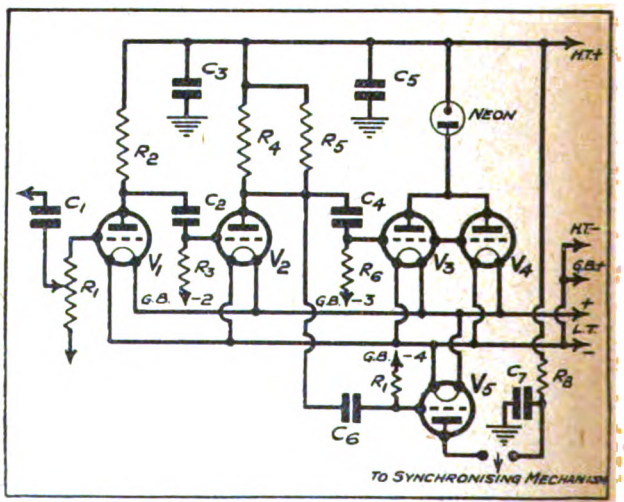

Fig. 1.—A suggested three-stage R.C. amplifier incorporating a separate valve for feeding the synchronising mechanism of the Baird "televisor" receiver.

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To What End?

By *A. F. Birch*

SURELY the most obvious truism with which to preface an article for publication in this journal is to remark that every day sees more and more scientific discoveries harnessed to the intimate life of the nation. The present enlightened generation are naturally more mechanically minded than in any previous period, and familiarity with Robotism has inevitably bred a contempt for the marvels thereof.

We do not wait nowadays for intricate instruments to be thrust upon us in our homes, we literally go out and look for them. The most complicated mechanism that is offered to us is quite placidly accepted provided its function is one calculated to add another pleasure or pastime to our everyday existence. The "instruments of the Devil" viewpoint has long since found an unhonoured grave. The fact that labour-saving contraptions have become a fetish in industrial concerns is quite comprehensible because they represent a money-making investment to the manufacturer, but in the home-life of the worker it seems strange to find so many appliances giving and expected to give reliable regular service, the possession of which not so many years ago would have been dubbed wizardry, and their owners fit subjects for the pillory, ducking pond, or even worse. Moreover, whereas previously a new departure of science was more often than not heralded with a dubious scepticism on the part of the public, this is now replaced by an intelligent interest in, and desire to possess, anything having a utilitarian value.

Merely compare the excited agitation and pros and cons throughout the country at the advent of the steam engine (a really quite comprehensible machine) to the calm reception of wireless telephony, the whys and wherefores of which have to be grasped by the average person in his imagination only or by the results obtainable from his receiving set. Other innovations which seem to call for similar comment are the automatic telephone, invisible burglar alarms (of the infra-red ray type), gramophone reproducers, even electric lighting and heating, not to mention talking pictures, flying, and the many and varied uses to which we put the internal combustion engine in our quest for pleasure.

These inventions would have confounded and confused the early Victorian mentality, but this generation has managed successfully to dovetail the miraculous into the everyday, and withal a bountiful science continues daily to add to our already rich possessions.

It is a subject which has before and may still provide us with abundant subject-matter for thought, to gaze retrospectively ahead and astern along the highway marked out for us by this progressive civilisation of ours. Looking back we see the mechanical era struggling to evolve from its chrysalis state in the middle and end of the nineteenth century and slowly emerging, but oh so slowly, from that stage during the first few years of the twentieth century, its progress hindered considerably by the "ca' canny" outlook of the wiseacres of the period, who could see little good and much harm resulting from the general speeding up of existence indicated.

Then the cataclysm of 1914-1918 descended upon us. Undoubtedly the war did much towards finally disposing of the anti-progressive point of view. The youthful "mechanica" emerged from the strife triumphantly, received encouragement from all directions, and has since blossomed forth as a beneficent genii endowed with wondrous powers. In fact the post-war period has been marked by so many scientific strides and adaptations that it is daily becoming harder even for the initiated to keep abreast of the tide. We live in a veritable maze of marvels.

Now to peer ahead along the unbeaten road stretching before us. Whither is this forward urge guiding us? This is a more difficult task and few people are

One of the pictures sent from Berlin to London by the new photo-telegraphy service which was opened on January 7th last.

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sufficiently gifted to foretell the vista which the first turn of the road will unfold, let alone the whole journey. We can only gauge an approximation thereof from our present surroundings after examining the beaten track which led to them, and rely on our intuitive judgment for the rest.

The writer's ego is not of the calibre which encourages the indulgence of farseeing predictions beyond those for which training and environment qualify him, so that we will not venture ambitiously to decide whether Utopia or Armageddon awaits us at the cross-roads. We can, however, endeavour calmly and impartially to look ahead and discuss the prospect in so far as one scientific gift to civilisation is concerned I refer to television.

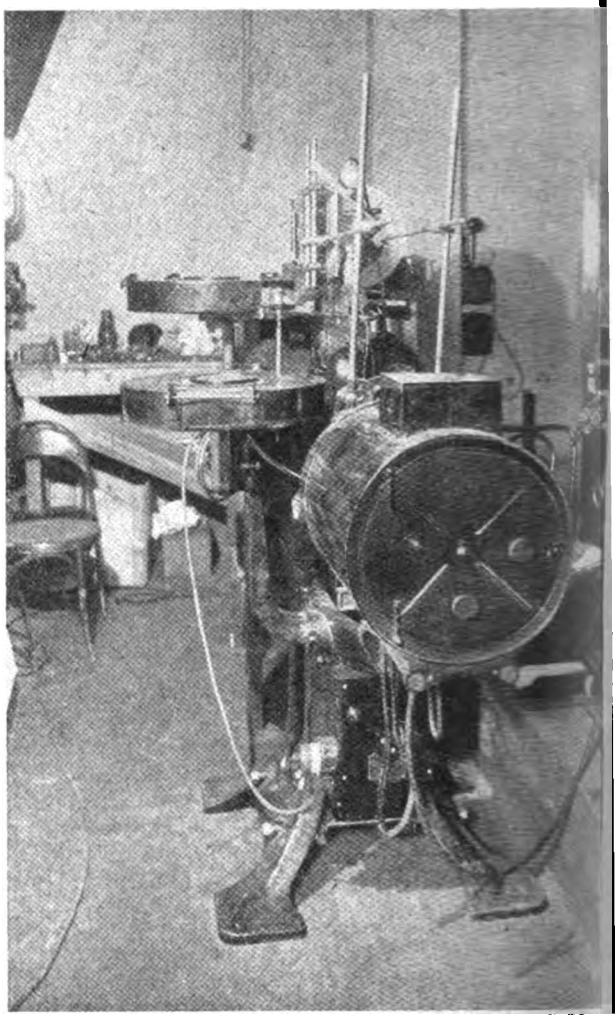
This invention of a Scotsman is one possessing such epoch-making potentialities that perhaps the talented inventor can find it in his heart to forgive those of us who inadvertently reverted to the mid-Victorian viewpoint in our reception of his offering. It meant our conceptions were still insufficiently expansive to cope with the idea in a concrete form.

It is interesting to quote again the chrysalis simile in connection with television. The science has definitely been in such a state for several years. Its emergence was postponed chiefly by sceptically antagonistic influences (many bigotted) but, of course, eventually it could not be withheld. How much quicker it would have emerged in a warm sympathetic and welcoming atmosphere to which, in view of the world's present mentality towards the creations of science, it was surely entitled.

The time is bound to come when people will look back on Mr. Baird's critical belittlers as amusing pagans handicapped by stunted imaginations. The sadder aspect of this, however, has been the fact that a scientific genius, instead of being encouraged to devote all his resourceful energy towards developing and perfecting his invention, has perforce had to give a large proportion of his personal attention towards the conversion of unbelievers in television. To such a man this must have been a wearisome and heart-aching business, calculated to deter many with a smaller measure of courage and determination.

As responsible technician during most of the television demonstrations in this country within the last year or so, the writer can bear witness to the patient courtesy displayed by the inventor in effecting these conversions, irksome and monotonous though they must have been at times. Admittedly there have been those few people who, after having seen the tangible results on the screen, still maintained their scepticism under the guise that its scope at present was limited, a flicker was seen, and other petty objections, but really these were more to be pitied than not. Their mentality would expect George Stephenson's " Rocket " to put up the performance of the " Flying Scotsman," and Wilbur Wright's first aeroplane to bring home the Schnieder Trophy.

As we know, the fight to secure the long-delayed official recognition for the Baird system of television is ended. The first broadcast of a regular service nature through a B.B.C. station determined that. And for the rest—surely it is the most apparent



A tele-talkie transmitter installed in the New York studios of the Baird Television Corporation of America.

thing in the world—that for such an invention there is no turning back. From now on there are only progressive milestones to be registered.

What we wish to foresee is if, how, and to what extent television will revolutionise our home life. We can, generally speaking, category our pleasures and pastimes into two distinct groups, indoors and out-of-doors. Of recent years we find that to the list of normal indoor home attractions have been added wireless and the gramophone, whilst outdoor attractions have been swelled by the movies, motoring, dog-racing, outboard boating, the dirt track and sundry others, the balance heavily on the out-of-doors side of the scales. A small matter, perhaps, but undoubtedly television will tend to even up matters in this respect for those able to afford it.

A complete television receiving outfit will unfortunately be an item of expenditure not within the means of all of us, but even so, neither is a car, and the installation will not cost anything approaching so much as that. Those of us unable to afford a car are restricted to other means of transport. Similarly, until we are able to purchase a televisor, we must

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content ourselves with cinemas for our screen entertainment. It is no condemnation either to ourselves or to the invention that we cannot pick up television on our crystal sets. A televisor must be regarded in the same light as a car, in so far that it will be an extra reward for thrift, and a visible sign of prosperity in its possessor.

At present the television screen is viewed through a lens, and at most four persons are able to see at a time. An early modification will undoubtedly be to have a fair-sized screen placed at one side of the room and to focus the received image on to this from the other, and so provide enjoyment for a room full of people. A more brilliant type of neon lamp is the main requirement needed to accomplish this.

A finer grained and detailed picture will be possible as soon as the sideband problem is surmounted or circumvented, and there is evidence that this will come about sooner than is generally anticipated.

The broadcast entertainment provided will consist of current events seen and heard instantaneously at first hand, likewise plays, etc., from the B.B.C. studios and theatres. Public personages will similarly be seen by audiences of millions. Sound films, or extracts therefrom, will be periodically presented over the ether, the B.B.C. transmitting these under an amicable arrangement with film-producing interests.

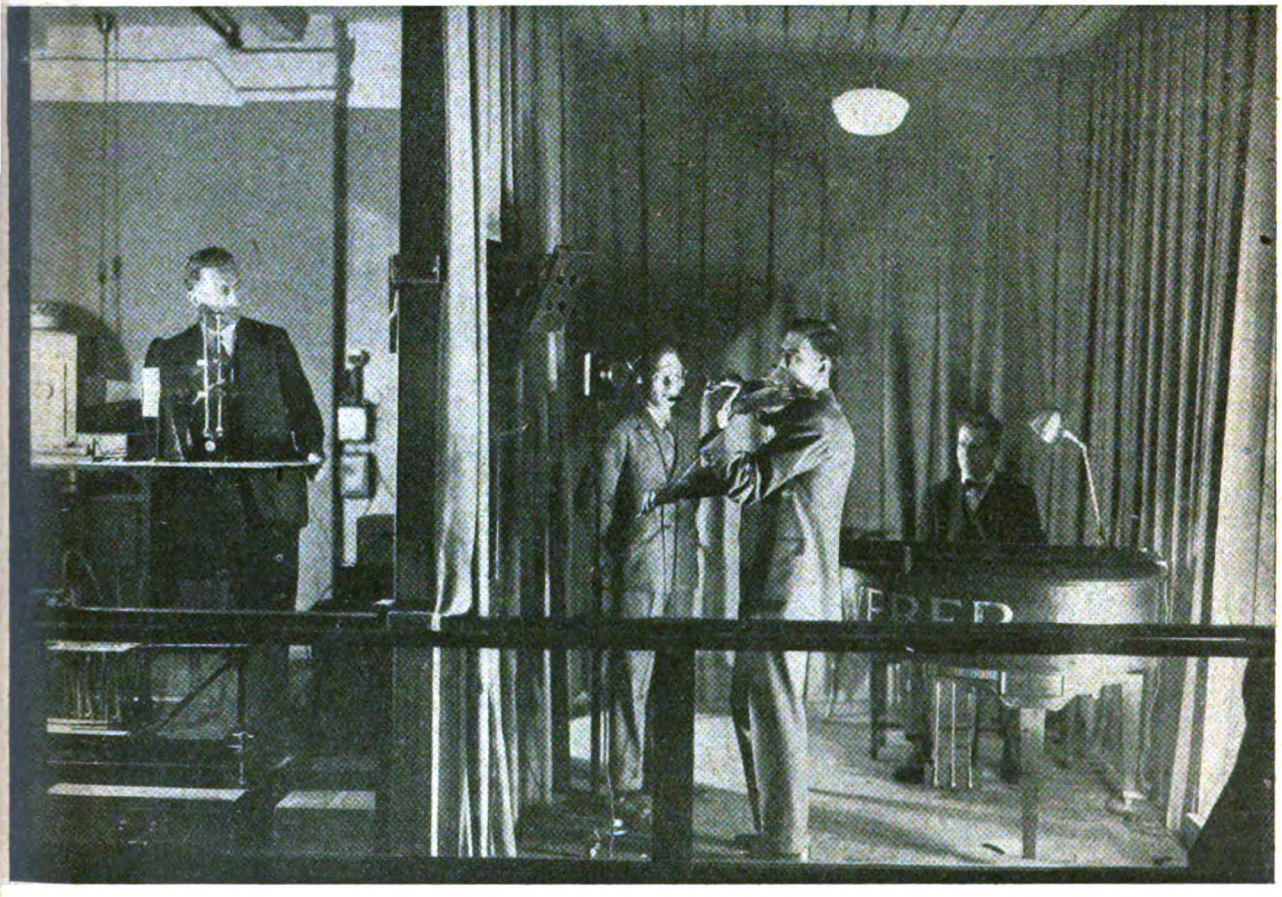
It is unlikely that in so doing that damaging effects will be felt in the film industry any more than the gramophone industry was harmed by the broadcasting of records. It is possible that cinemas will be equipped to enable them to relay broadcast news events to their audiences, although one hesitates to prophesy that there will be a wider application on public screens than this.

All in all, television will provide the necessary adjunct to ordinary broadcasting to supplement the powerful fireside inducement which this exerts over so many of us. An extra luxury will be within reach whose influence will prove to be entirely beneficial in both these and its other applications.

More news: "When talking films are broadcast with the aid of television, one London hotel will be ready to let their guests see and hear whenever they feel so inclined." The guests had better take care in case they are transmitted.

* * *

We are told that the B.B.C. is looking for a wireless programme in the talking-picture world. To train the imaginations of listeners.



A general view of the television studios and transmitting room in New York of the Baird Television Corporation, showing an actual transmission in progress. It will be noted that these studios are arranged in a manner similar to the studio used by the Baird Television Development Company to demonstrate television near Olympia, London, during the period of last year's Radio Exhibition.

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High and Low Tension Accumulator Hire and Maintenance

The Romance of a Novel Enterprise

WHEN broadcasting commenced seven years ago one of the biggest difficulties the wireless user had to contend with was the proper and careful charging and maintenance of the accumulators. Expensive accumulators were in many cases ruined in a few months by unskilled charging. Nothing was more annoying to the enthusiast than to find that the accumulator failed him when he had succeeded in securing good reception after hours of patient work.

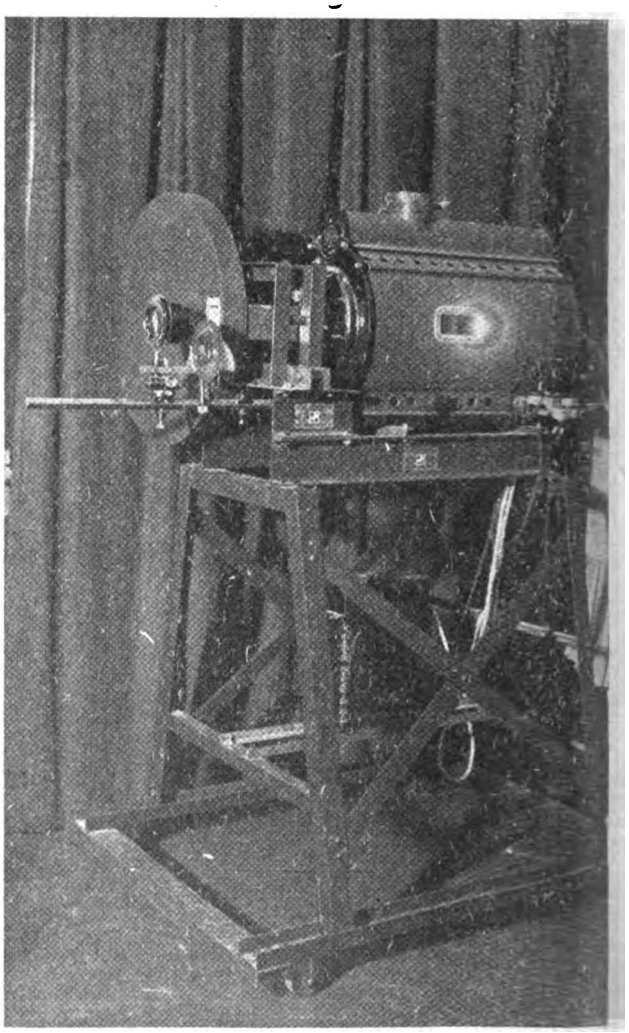
One of these enthusiasts, having experienced the above troubles, conceived the idea of establishing a business devoted entirely to the hire and maintenance of wireless accumulators, at such prices as would show a saving of approximately half the cost of buying one's own accumulators, and having them ruined by unskilled recharging ; combined with regular collection and delivery by motor transport in the London area.

Accordingly, small premises were taken in Camden Town, and converted for this purpose. The large number of orders received, immediately proved the urgent need for such a unique service, and at the same time provided the founder with many difficulties to overcome, in order to meet the demands. The primary difficulty was to secure an adequate stock of batteries. This necessitated a tour of many battery manufacturers and agents in London, to purchase their entire stocks irrespective of make or size. The next difficulty was the charging of such a large number of accumulators. Every bank was filled to capacity, charging going on night and day ; even the radiator used for heating the office was brought into commission, the batteries being wired up in series with this radiator.

In a very short space of time, larger premises had to be taken, and the firm of Radio Service (London), Ltd., of 105, Torriano Avenue, Camden Road, N.W. 5, came into existence. Every requirement of the wireless user was now provided for, and the delivery radius extended to 12 miles from Charing Cross.

A special type of low tension accumulator was designed purely for use in connection with wireless, and it now became possible to hire any size of these specially designed batteries. In addition, customers having only one accumulator were assured of a continuous supply by joining the part-hire service, having one of the Company's batteries alternately with one of their own. Those who possessed two accumulators secured the benefits of skilled charging and maintenance, coupled with a much longer life of their batteries, in addition to which regular collection and delivery was guaranteed.

About this time a new service was introduced, which improved reception beyond belief, namely, the hire of high tension accumulators in place of unreliable dry batteries. With these accumulators stronger and clearer reception was secured, and all irritating and crackling loud-speaker noises disappeared entirely.



A photograph just received from America showing a new transmitter developed by the Baird Television Corporation of America. Note enclosed disc.

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The cost of hiring these accumulators worked out at no more, and in most cases less, than the cost of dry batteries. The inauguration of this service resulted in 1,100 applications being received in two days.

To-day this Company has over 10,000 satisfied subscribers, catered for by the largest battery-charging station in the country; eight large vans deliver daily with practically clockwork precision, making 10,000 calls fortnightly.

In addition to this service, all classes of wireless repair work are carried out with the same care and promptitude. It can be genuinely claimed that this service saves the wireless user both money, time and trouble, and it is the safe and certain way to secure both L.T. and H.T. current. It will also prove invaluable to users of television, where a continuous supply of high and low tension current at a constant voltage is required.

Says a critic: "It is as yet too early to speak in detail of the probable effect of television on entertainment." More opera glasses.

* * *

She: "When a man who bores me asks where I work, I always say 'In a television laboratory.'"

He: "Aha! That shuts him up, I expect. But where do you work?"

She: "In a television laboratory!"

FORTHCOMING LECTURES.

Lectures on television will be given as follows during the month of February:—

Mr. J. J. DENTON, A.M.I.E.E., Joint Hon. Secretary of the Television Society.

February 26th.—Conway Hall, Red Lion Square, W.C.2.

Mr. A. DINSDALE, A.M.I.R.E., Editor of TELEVISION, has the following engagements:—

Feb. 6th.—Beacon Hill Village Club, Hindhead, Surrey, at 8 p.m.

Feb. 10th.—St. Mary's Hall, Coventry, at 8 p.m.

Feb. 11th.—The Institute, West Bromwich, Staffs., at 7.30 p.m.

Feb. 13th.—Moseley and Balsall Heath Institute, Moseley, near Birmingham, at 7.30 p.m.

Feb. 14th.—The Co-operative Hall, Fleetwood, Lancs., at 7.30 p.m.

Feb. 19th.—New Church Sunday School, Accrington, Lancs., at 7.30 p.m.

Feb. 25th.—Y.M.C.A., Aberdeen, at 8 p.m.

Feb. 26th.—Parish Hall, Elgin, Morayshire, at 8 p.m.

Feb. 28th.—Town Hall, Dingwall, Ross-shire, at 8 p.m.

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Letters to the Editor

APPRECIATION FROM AMERICA.

To TELEVISION PRESS, LTD.,
26, CHARING CROSS ROAD,
LONDON, W.C. 2, ENGLAND.

GENTLEMEN,–I ran across your magazine, TELEVISION for November, in a local news stand, and really enjoyed it very much. It is the first British magazine on the subject of television I have seen. Being a radio service man for eight years, I am naturally an ardent student of television. I raid the news stand for any book on it, which are very few here.

Television is progressing fairly well here. So far it is worked on short waves only, between 40 and 150 meters. Sometimes it comes through on the regular wave band, but it is always during working hours, so I haven't had a chance to try my own outfit yet. The nearest station to me is in the city of Chicago, sixty miles away. They put on a test once in a while. There is not enough television transmission available here in the mid-western states for us to experiment on, as yet, but I hope they do soon.

I intend to construct an experimental station of my own for my own use. I am looking forward to new issues of your magazine. I remain,

Yours truly,
D. L. GILBERT.

681, N. Harrison Avenue,
Kankakee, Illinois, U.S.A.

OUR NEW COVER.

To the Editor of TELEVISION.

DEAR SIR,—As a recent reader of this paper I should like to congratulate you on your new cover design.

My interest in television was first roused when I visited the Berlin Radio Exhibition last September and saw various methods of television there. Since then I have been an ardent reader of your valuable paper. I always look forward to the next number of this magazine with great eagerness, and I only wish that TELEVISION would appear weekly instead of monthly.

I am, yours truly,
ERNEST H. TRAUB.

Fernhill, 34, Dartmouth Road,
London, N.W. 2.

January 13th, 1930.

To the Editor of TELEVISION.

DEAR SIR,—As I could not find TELEVISION for January upon the stall of my newsagent, I asked the youth in charge for a copy of it. "Why, sir," he said, "there's a copy right before your eyes," and indeed he was right. For what I saw now was not a new, lurid-covered, boys' scientific journal, such as, for instance, "Amazing Stories," "Scientific Adventures," etc., but TELEVISION with a new cover.

But, seriously, do you intend to keep this cover (well meant, no doubt), hoping to attract all and sundry with such a picture? Frankly, I consider the former cover times over again much better. Indeed, the original cover was designed by a genius, so softly shaded, with the stage in the background and the televisor in the foreground, conveying a sense of space, bridged. Anyway, what matter the cover if what is underneath is worth reading, but really . . . .

Yours well meaningly,
H. MILLER.

P.S.—The first thing I did was to tear off the new cover. No, not to frame it!

190, Rock Avenue,
Gillingham, Kent.

January 7th, 1930.

NAME OF A NAME!

To the Editor of TELEVISION.

DEAR SIR,—With reference to applying a name to the radio-television-gramophone set referred to in your December number, may I raise a protest against the objectionable word Gravideorad.

I venture to propose Radiographoscope, as being more suitable, pleasant-sounding, and etymologically permissible. Its derivation is simple and requires no explanation, and contains but one more syllable and five more letters than the other word.

Gravideorad, on the other hand, is a harsh and ugly word, and contains two hideous abbreviations, with a spun-out word in the middle; it has no proportion, and a syncopated balance which is untrue.

Television is a very badly-named science in every way, but that can be put right in time, if only we spend a moment's thought and a little trouble in choosing a pleasant name instead of illiterately grabbing at some harsh, vulgar and impermissible noise.

I am, yours very sincerely,
A. J. C. SHERED, S.M., Iv.S.

Dundaff Muir, Camberley,
Surrey.

January 7th, 1930.

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To the Editor of TELEVISION.

DEAR SIR,—In answer to your request for a name for the gramophone-television-wireless set, I offer my suggestion Gramoradioviser, as being a name which would be understood by the man in the street.

Yours truly,
L. ROSEWORTHY.

20, Queen's Road,
Walthamstow, London, E. 17.

January 8th, 1930.

To the Editor of TELEVISION.

DEAR SIR,—Might I suggest "Gradivid"—Gra (gramo.), radi (radio), vid (video, I see)—for the instrument in question.

Yours truly,
C. SKELLY.

Y.M.C.A., Dale End,
Birmingham.

To the Editor of TELEVISION.

DEAR SIR,—You may be interested to know that I am successfully receiving the Baird transmissions of television broadcast twice weekly from Brookman's Park on a home-made television receiver.

My success is due in a large measure to the very excellent articles published from time to time in your journal and to experimental work on my own account.

I may also add (for perhaps the assistance of other experimenters) that I find it unnecessary for experimental purposes to purchase a special neon lamp, but I am using with great success an ordinary commercial Osram figure "8" type neon lamp, and by reflecting back the glow from the reverse side of the plate with a cheap concave mirror I am able to "fill up" the slots forming the "8," thus giving to all intents and purposes the appearance of a flat glowing plate.

By this simple device I am enabled to get very good detail and a bright image, the smoke from a cigarette, held by the person being televised, being clearly visible.

I am endeavouring to photograph my received image, and, if successful, I will forward a print to you.

Yours faithfully,
A. R. KNIPE.

5, Southsea Avenue,
Leigh-on-Sea.

January 19th, 1930.

To the Editor of TELEVISION.

DEAR SIR,—I have read with great interest the article on "The Polarisation of Electro-Magnetic Waves" by your contributor, Mr. Smith-Rose, in your issue of January, 1930.

I think however, that your readers should be informed that his conclusions on page 533, viz., "that horizontally polarised waves can be transmitted over the earth's surface only with difficulty, if at all, and that the effect of such waves is entirely negligible compared with the effect of any vertically polarised waves emanating from the same transmitter," are at variance with the experiments carried out by Dr. Alexanderson, and also those by the United States Department of Scientific Research.

Dr. Alexanderson found that the horizontal radiation gave better service in the zone from 60 to 250 miles from Schenectady, whilst at greater distances the vertical antenna radiation was more satisfactory.

The U.S. Department of Scientific Research extended the experiments to the longer waves up to 15,000 metres, and found that in certain circumstances a plane polarised wave may be transformed to an elliptically polarised wave, this being, of course, due to the presence of two components out of phase.

You would, I feel certain, wish that your readers should be in possession of all available data on the subject, hence this letter.

Yours faithfully,
C. G. PHILP.

Television Demonstrations in Glasgow

The First Scottish Electrical, Wireless, Engineering, Musical, Photographic and General Trades Exhibition will be held in the Kelvin Hall, Glasgow, between January 29th and February 8th, 1930. The exhibition will be opened by Lady Inverclyde.

This exhibition, being the first of its kind, will be of great interest to our Scottish readers, and more especially so in view of the fact that the Organiser, Mr. John R. Mungo, has arranged with the Baird Television Development Company to give demonstrations of television in the Kelvin Hall during the period of the exhibition.

At the meeting of the British Association held in Glasgow in September, 1928, Mr. Baird personally demonstrated to members of the Association his two latest scientific achievements, stereoscopic television and colour television. The forthcoming exhibition however, will be more especially noteworthy in that it will provide the first opportunity for the citizens of Glasgow to witness commercial television.

We understand that the television demonstrations will be open to members of the public at certain specified times daily, and as only a limited number of people can be accommodated, the exhibition authorities have decided to make a charge of sixpence per head for admission.

Lord Angus Kennedy, Vice-President of the Television Society, will be present at the exhibition.

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Invention and *Development*

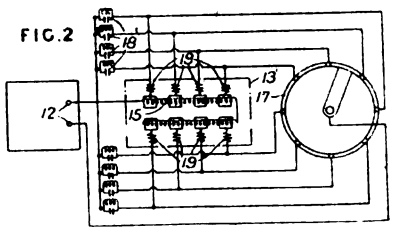
The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, W.C.2. Price 1s. each.

SEVERAL enquiries having come to the writer of these Notes regarding Patent No. 316,340 (November TELEVISION), all of which request further information, it should be stated that the abstract was prepared from the available information published, and was inserted in these Notes in the hope that some reader would be able to elucidate the various points which seemed obscure. For any further information the reader is referred to the full published patent specification.

FIG.1.

Patent No. 321,196, granted to J.L.BAIRD and TELEVISION, LTD. Fig. 1 shows a neon discharge tube having a concave reflecting anode (2) and a ball-shaped cathode (4), the latter being situated approximately at the focus of the reflector. Conducting supports (6) (8) for the electrodes are insulated above the pinch (12) by glass tubes (14) (16). In a modification, a rod-shaped cathode is situated in the axial focus of a part-cylindrical anode, which is secured by three supports. To concentrate the glow upon the front of the reflecting anode, the back of the latter may be coated with an insulating material such as mica or micanite, which may be secured by metallic clips. When used with television apparatus, the reflecting anode may be larger than the viewing aperture.

FIG.2



Patent No. 321,194, granted to J. JOHNSTON. To prolong the illumination of neon or other lamps forming a receiving screen (13) in Fig. 2, after the received impulses have been distributed by the commutator ring (17), each lamp is provided with a shunt reactance element such as a condenser (18), with or without an inductance in parallel with this condenser, and with or without a resistance (19). One terminal (12) of the receiving apparatus, such as a valve amplifier, is connected to a common lamp electrode (15). Certain areas of the screen may be scanned at different frequencies.

Patent No. 321,138, granted to J. L. BAIRD and TELEVISION, LTD. The scanning devices at the transmitter and receiver of a television apparatus are run so that the speed of one is a sub-multiple of the speed of the other. If the scanning mechanisms are identical, and the speed of the receiver is a sub-multiple of that of the transmitter,

FIG.3.

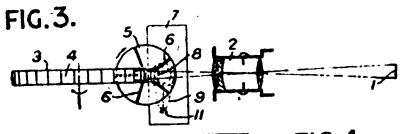
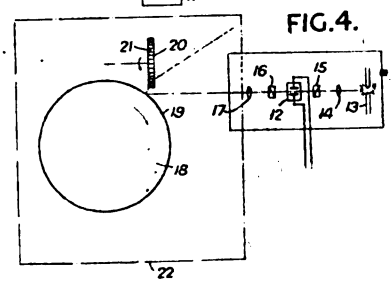


FIG.4.



multiple images are formed at the receiver, all but one of which may be masked out. On the other hand, the receiving mechanism may have the appropriate number of complete sets of light-apertures so that a single reduced image of equivalent detail to that transmitted is reproduced at the receiver.

Patent No. 320,999, granted to J. S. SHINTON. In a television transmitter (Fig. 3) images are intermittently reflected on to a selector device, comprising a stationary slot and a rotating slotted disc. The image of an object (1) is projected by a lens (2) on to the edge of a rotating wheel (3) having a number of mirrors (4) arranged tangential to the rim and parallel to the axis of rotation. As the wheel rotates, each mirror reflects and focusses the image on a disc (5), rotating about an axis perpendicular to that of the wheel, and provided with radial or other slits (6) overlapping a slot (8) in a fixed member (7). Behind this member is a light-sensitive cell (9). It is stated that wheel (3) may rotate at 2,000 revolutions per minute, and disc (5) may have five slits and rotate

FIG.5.

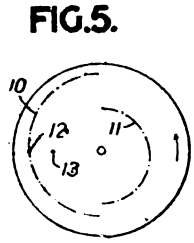
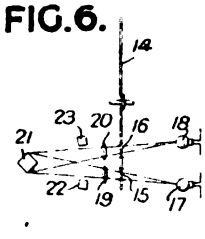


FIG.6.



at 60 revolutions per minute. The receiver is shown in Fig. 4. Light from a source (13) passes through a lens (14), polarising Nicol (15), Kerr cell (12), analysing Nicol (16) and lens (17) on to a wheel (18) similar to that at the transmitter. The output of the photo-cell (9) is applied to the plates of the Kerr cell. Modulated light-signals are reflected by the tangentially arranged mirrors (19) on wheel (18) to further mirrors (21) on the edge of wheel (20) (which is rotating about an axis perpendicular to the former wheel) and thence to a receiving screen (22). The wheel (20) may have 30 mirrors and rotate at 10 revolutions per second.

Patent No. 321,389, granted to J. L. BAIRD and TELEVISION, LTD. Details are given in this patent specification of the system used for producing images in natural colour by using a number of light-sensitive cells of different colour sensitivity, and a number of correspondingly coloured lamps at the receiver,

FIG.7.

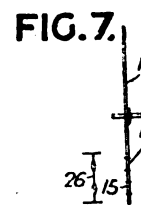
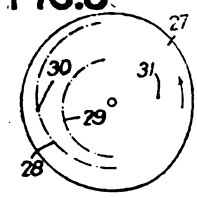


FIG.8.



the correct re-combination of colours being secured by an arrangement of slip rings and commutator.

Patent No. 321,441, granted to J. L. BAIRD and TELEVISION, LTD. In stereoscopic television, two aspects of an object or scene are transmitted successively through a single communication channel and reproduced side by side at the receiver, some 12 images of each aspect being sent per second. The scanning disc (14), Figs. 6 and 7, is provided with two sets of holes (10) and (11) shown in Fig. 5. lying on spirals whose " operative points " are (12) and (13) respectively, and which are spaced any desired distance apart, as for example, the spacing of the human eyes. In the transmitter (Fig. 6) the light-sources (17) (18) scan the object (21) alternately through the spirals (10) (11) from a different angle. Light reflected from the object is received by the light-sensitive cells (22) (23). At the receiver (shown in Fig. 7) glow discharge lamps (24) (25), used in conjunction with an identical scanning disc (14), produce two images in alternation which are side by side, and are viewed by a stereoscope (26). Exaggerated stereoscopic effects may be obtained by using scanning discs of the type shown in Fig. 8, where (30) (31) are the widely spaced " operative points " of the spirals. Colour effects can be obtained by using a red and blue filter, one on each set of holes. Details are given in the specification for using a three-colour process.

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